DIGEST

OF

HUMAN PHYSIOLOGY.

BY

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WITH 48 ILLUSTRATIONS AND SOME COLOURED PLATES

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RESPECTFULLY DEDICATED

TO

COL G. HUTCHESON, M.D., C.M., I.M.S.,

INSPECTOR-GENERAL OF

CIVIL HOSPITALS,

N W. P. AND OUDH.

PREFACE.

It may be thought that a great number of Text-books on Physiology are already current. Why therefore add another? The author ventures to lay his opinion that a work such as this is a distinct want in the student world. One of the great objections to most of the text-books is that they are either far too bulky to be conveniently and readily carried about by the students, or, if not too bulky, they are far too sketchy in character. Neither of these objections can be raised against this little work. It is small in bulk, but is a perfect store of information in most accessible and comprehensive form, not only to the preparatory students, but also to the practitioners. The aims of the author of this little work are therefore two-fold :—

(1) To enable the students to digest the essential points of physiological facts in a most concise manner while preparing for their examinations.

(2) To enable the busy physicians to refresh their memory on the physiological aspect of medicine.

The text contains a compilation of facts bearing upon the more important subjects with

the addition of such hints as have occurred to him likely to be useful to the students.

In writing this work, he has gained his information from leading text-books and monographs, such as Londois Stirling, Halliburton, Nettleship, Field, Gower, Horsley, Feriar, Byron Bramwell, Schafer, Rutherford. He trusts that he has sufficiently acknowledged that the author does not claim any originality in this vast subject, but still he thinks he can claim presenting the text original in character.

He has no right to expect leniency from his critics, but he begs that they will not judge this work by too high a standard. He hopes they will appreciate it as an honest attempt in presenting to the public the main facts of physiology in such condensed and comprehensive way that students need not spend valuable time in grinding voluminous books at the time of examination. He will feel grateful to those critics who find any error in the work and kindly communicate it directly to the author

In conclusion, he heartily commends the work *per se* to the attention of medical and scientific students, and wish that it may speedily become popular.

The author does not like to omit the opportunity of expressing his sincere gratitude and warm affection with high esteem encentred in his heart for his uncle, S N. Huda, Esq., I.C.S., B.A., LL.B (Cantab.), BARRISTER-AT-LAW, District and Sessions Judge of Bengal, who took a

great interest in giving scientific education to the author, and in bringing out this work. In conclusion, he returns his thanks to the publishers and printers of this work for courtesy at all times.

LUCKNOW,
12*th March*, 1901

S. M. VARIS.

ERRATA.

ORIGINAL	READ
Page 27, line 14 (3), relax*ed*	relaxed
„ 42, line 29, artery *as a* transparent	artery is a transparent
„ 44, line 16, vas*o* vasorum	vasa vasorum
„ 46, line 6, thora*cio*	thoracic
„ 100, line 30, frœ*m*um	frœnum
„ 104, line 22, ptyl*ine*	ptyline
„ 127, line 19, ty*ra*sine	tyrosine
„ 232, line 10, am*ti*tude	amplitude
„ 245, line 20 (ma*culatutia*)	(macula lutia)
„ 249, line 24, *and* soft, rounded	soft and rounded
„ 261, line 16, visual ocuity	visual acuity
„ 290, line 3, *Sor*colema	Sarcolema
„ 293, line 22, *On* active	An active
„ 300, line 17, *fos*ciculi	fasciculi
„ 303, line 11, serves *then*	serves them
„ 320, line 31, *m*pulses	impulses
„ 106, line 14, *um*boiled	unboiled

The readers of this book will be kind enough to pardon me for these mistakes, as they have escaped notice while revising proofs

S M VARIS

CONTENTS.

CHAPTER I.

PHYSIOLOGY OF THE BLOOD

The blood is the great medium by means of which all the tissues of the body are nourished "Into it are poured those substances which had been subjected to the action of the digestive fluids, and in the lungs or other respiratory organs it receives oxygen It thus contains new substances, but in its passage through the tissues it gives up some of these new substances, and receives in exchange certain waste products which have to be got rid of Besides carrying the new nutrient fluid to the tissues, it is also the great oxygen-carrier as well as the medium by which some of the waste products, *e g* , CO_2, were removed from the tissues and brought to organs, *e g* , lungs, skin, kidneys, which eliminate them from the body "

THE AMOUNT OF BLOOD IN THE BODY

The total amount of blood in the body is about one-thirteenth of its weight, *i e* , for an ordinary person it would be about 13lb At birth it is said to be about one-nineteenth the weight of the body

PHYSICAL CHARACTERS OF THE BLOOD

It is scarlet red in the arteries, dark, bluish-red in the vein Oxygen makes the blood bright-red , want of oxygen makes it dark It is homogeneous, viscous alkaline in reaction, owing to the presence of disodic phosphate, (Na_2 HPO_4) and bicarbonate of soda, and reaction becomes acid after death It has saltish taste, its specific gravity is 1055, and its temperature 100^0 F It has a peculiar odour

MICROSCOPIC EXAMINATION

It consists of corpuscles, red and white, floating in a fluid called Plasma or Liquor Sanguinis, together with the blood-plates or platelets

FEATURES OF WHITE CORPUSCLES OR COLOURLESS OR LEUCOCYTES

They consist of—

(1) Nucleated masses of amœboid granular protoplasm

(2) They have no apparent envelope, as the processes they protrude may be observed to fuse at their apices, when they happen to collide their shape, therefore, is indefinite

(3) Usually three nuclei

(4) Size $\frac{1}{3200}$ to $\frac{1}{1600}$ of an inch, or from the same size to twice the size of the coloured corpuscles

(5) They are inelastic, and viscous sticky, and tend to cling to the sides of the vessels

(6) They are lighter than the red corpuscles

(7) They envelope and eat solid particles

In health, the proportion of white to red corpuscles is about 1 to 500 or 600

THE AMŒBOID MOVEMENT

The movements are called amœboid, because they are typically seen in the amœboid The movements consist in a protrusion of processes of protoplasm, which are again retracted and other processes protruded In this way the corpuscles can migrate from place to place, or even pass through the walls of capillaries into the surrounding tissues It is called Diapedesis This emigration is best marked during the process of inflammation

PUS CELLS are also identical in structure with white blood corpuscles

ACTION OF REAGENTS—Water when added slowly causes the colourless corpuscles to become globular By treating them with dilute acetic acid, or a dilute caustic alkali, the protoplasm clears up, and nuclei are thus brought into view

FEATURES OF HUMAN RED BLOOD CORPUSCLES.

1 They are circular bi-concave discs, but have no amœboid movement, red in mass, but pale yellow when seen singly They are composed of a colourless, structureless, and transparent fram-work, or stroma, infiltrated by a red colouring matter called hæmoglobin.

2 They have a thin, clear, soft, extensible, but perfectly elastic envelope

3 They have no nuclei

4 Size as an average $\frac{1}{3200}$ of an inch in diameter

5 They are extensible and perfectly elastic, and have a smooth, non-viscous surface, and readily glide past each other in the blood vessels

6 They are heavier than colourless corpuscles,—specific gravity 1088

RED BLOOD CORPUSCLES OF MAN AND THE LOWER ANIMAL

In man and all mammals they are circular and bi-concave disc (in the camel they are oval) In all other vertebrates they are oval and bi-convex, and are nucleated

NUMBER OF CORPUSCLES

A cubic millemeter of blood contains five million (5,000,000) of coloured corpuscles and about 10,000 colourless In the blood generally, the colourless are in the proportion of 1 to 500 of the coloured The corpuscles are counted by an instrument called *Hæmacytometer*

FORMATION OF ROULEAUX

A very common phenomena in shed blood is the tendency of the corpuscles to run into rouleaux, *i e*, the red cells tend to run together into piles, like piles of coins. The running into rouleaux is due to their shape

EFFECTS OF REAGENTS

1 Water renders red corpuscles spherical and dissolves out the Hæmoglobin.

2 Acetic acid renders them clear and transparent, and dissolves out the Hæmoglobin

3 Saline solution (2—3 per cent) makes them crenated

DEVELOPMENT OF RED CORPUSCLES IN EMBRYO

Before the development of the liver and blood glands, red blood corpuscles are produced directly from the mesoblastic cells, and from white blood corpuscles and by fessiporous division of themselves throughout the body generally

The nuclei of certain cells multiply, and then this multinucleated mass differentiates into a central mass of nucleated young red blood cells, while the outer part becomes wall of the future capillary To form blood-vessels processes grow out from this wall, at first solid, but become hollow and filled with plasma and corpuscles

When the liver begins to be developed, the multiplication of cells ceases, and new blood-cells are produced by the liver and blood glands

THE FUNCTIONS OF CORPUSCLES

The red are oxygen-carriers from the lungs to the tissues by means of loose combination between the hæmoglobin and the oxygen The white produce the red, and in some cases may emigrate from the vessels and take part in the formation of new tissues.

THE PROPORTION OF CORPUSCLES

About one-third consists of corpuscles and two-thirds liquor sanguinis As it is said above that corpuscles are floating into a fluid called "Liquor Sanguinis" or Plasma

THE CONSTITUENTS OR "LIQUOR SANGUINIS"

The plasma is alkaline, yellowish in tint

It consists of—(1) Water and trace of glucose

(2) Salts—Sodium, and potassium chloride, carbonate, sulphate, phosphate, calcium phosphate, magnesium phosphate

(3) Proteids—
  (a) Serum-albumen
  (b) Serum-globulin
  (c) Fibrinogen (Elements of fibrin)

(4) Small quantity of fat—
  (a) Olien, (b) Palmatin, (c) Stearin,
  (d) Lecithin

(5) Effete matters, as urea, uric acid, hippuric acid, creatin, creatinin xanthin, hypoxanthin, cholesterin

BLOOD PLASMA OR LIQUOR SANGUINIS AND ITS RELATION TO SERUM

BLOOD PLASMA is the liquid part of living blood, or blood in the living body in which corpuscles float This fluid, however, after blood is withdrawn from the vessels, rapidly undergoes a change, owing to the formation of a solid fibrous substance called "Fibrin" After this occurs the new fluid, which no longer coagulates, called Blood Serum

This fluid consists of the same constituents as the plasma, but differing into the proteids, as it contains "fibrin ferment" instead of fibrinogen

HOW TO PREPARE "PLASMA"?

It may be obtained by exposing blood to low temperature The blood remains fluid, the coloured corpuscles subside in a few hours, while the "plasma" remains above as a clear layer, which can be removed with cooled pipette

HOW TO OBTAIN FIBRINOGEN?

Defibrinate blood with brush, so that fibrin is removed, serum and corpuscles are left, separate serum by Cream of Tartar

FATE OF THE RED CORPUSCLES

They are probably broken up in the spleen, from whence the pigment is conveyed to the liver to form bile-pigments

COMPOSITION OF RED BLOOD CORPUSCLES

(1) Water, (2) Solids, (3) Gases.

SOLIDS —(1) Hæmoglobin
(2) Paraglobulin
(3) Lecithin.
(4) Cholesterin
(5) Salts

THE GASES OF THE BLOOD

Oxygen, nitrogen, carbonic acid.

SALTS OF THE RED CORPUSCLES

The salts chiefly consist of chlorides of potassium and sodium, and phosphates of calcium and magnesium

WHAT IS HÆMOGLOBIN ?

It is the colouring matter of red cells It lies in the sponge-like mesh work of the cell It is by far the most important and abundant of the constituents of the red corpuscles

COMPOSITION OF HÆMOGLOBIN

It is an albumenoid substance, very complex, and consist of C H O N S F It forms 90 per cent of dried red corpuscles, and is soluble in water and serum It is crystalline In man forms elongated rhombic prisms It differs from proteids in containing the element iron.

THE CHIEF USE

It forms a loose compound with oxygen, and acts as the chief oxygen-carrier from the lungs to the tissues

QUANTITATIVE ESTIMATION OF HÆMOGLOBIN

The instrument used for estimation is called *Hæmoglobinometer* of Gower's It is very important in clinical examination for estimation of hæmoglobin or colouring matter

HOW CAN IT BE OBTAINED IN THE CRYSTALLINE FORM ?

It may be made to leave the corpuscles by shaking with water or ether, or by alternately freezing and thawing the

blood; this breaks up the corpuscles and sets the hæmoglobin free One-quarter of its bulk of alcohol is then added, and it is placed in a temperature of 0^0C to crystallise

THE CRYSTALS

They are of reddish colour, and in shape form elongated rhombic prism They contain iron (Fe) Soluble in water, and also in alkaline solution

THE PECULIARITY OF HÆMOGLOBIN

Though it is crystallisable, it is not diffusable, *i e*, its solution cannot pass through an animal membrane, and to that extent, therefore, it would seem to be of a colloidal nature, because the molecules of hæmoglobin are too large to pass through the pores of the membrane, they are certainly very complex, they are also, in part at least, composed of a proteid At the same time, if hæmoglobin be injected into an artery, it is excreted by the kidneys, and so must have passed through a membrane, but then the blood pressure in the kidney is very high

THE FORMS OF HÆMOGLOBIN (Hb)

It exists in human blood in two forms, one in loose combination with oxygen (=oxyhæmoglobin, HbO_2) and the other as reduced hæmoglobin The former occurs in arterial blood, the latter exists in the blood after asphyxia

THE BEHAVIOUR AND REACTIONS OF OXY-HÆMOGLOBIN UNDER VARIOUS CIRCUMSTANCES

Though it forms a loose compound with oxygen, yet it contains in addition to this oxygen as an essential part of its chemical composition It is scarlet in mass and yellow singly, it gives scarlet to arterial blood It is formed by exposing blood to air In a vacuum it is reduced, or at least loses the greater part of its loosely combined oxygen A stream of hydrogen, the addition of ammonium sulphide, an alkaline solution of ferrous sulphate, stannous chloride, and various other reducing agents make

it give up its oxygen, and it then becomes of a purplish-red colour both in solution and crystals The dark colour of venous blood is due to reduced hæmoglobin

THE SPECTRA OF REDUCED HÆMOGLOBIN AND OXY-HÆMOGLOBIN

Both are absorption spectra

In oxy-hæmoglobin the absorption bands are in the green part of the spectrum (between the solar lines D and E) the one towards the red side is the thinner Reduced hæmoglobin has a single broad dark band intermediate in position between the two, thinned off towards edges

THE SPECTRA OF ARTERIAL BLOOD AND VENOUS BLOOD

The spectrum of arterial blood is just the same as the spectrum of oxy-hæmoglobin, but the spectrum of venous blood is not the spectrum of reduced hæmoglobin, but like that of oxy-hæmoglobin, though there is a slight darkness towards the green (between the two dark bands) If an animal be asphyxiated, then after a time the blood shows a spectrum like that of reduced hæmoglobin

ACTION OF NITROUS OXIDE (N_2O) AND NITRIC OXIDE, CARBONIC OXIDE ON OXY-HÆMOGLOBIN —

1 NITROUS OXIDE ("laughing gas", N_2O) reduces the oxy-hæmoglobin, but does not combine with it, the purple appearance of the face, when it is inhaled, is due to the presence of reduced hæmoglobin

2 NITRIC OXIDE (NO) —It reduces the oxy-hæmoglobin, and also combine with the hæmoglobin and forms Hb NO The compound thus produced is more stable and less easily reduced

3 CARBONIC OXIDE (CO) not only reduces the oxy-hæmoglobin, but it combines with the Hb afterwards, forming a stable compound (Hb CO) As this is not an

oxygen-carrier, death may result from suffocation from the want of oxygen, notwithstanding the free entry of pure air into the lungs, the oxygen being unable to dislodge the carbonic oxide

GUAIACUM TEST OF BLOOD

To a little blood in a test tube add three drops of tincture of guaiacum and mix them, and then add a little ozonic ether to form a layer on the surface and let it stand without shaking Oxy-hæmoglobin causes a blue tint on a solution of tincture of guaiacum resin in the presence of ozonic ether, this is due to oxidation

DECOMPOSITION OF HÆMOGLOBIN

The substances that decompose hæmoglobin—

(1) Heat blood in open air, (2) heat with acids as acetic acid or alkali, *e g*, caustic potash It decomposes into many substances, but the two chief are—

(1) A proteid called Globin

(2) A pigment called Hæmatin contains iron

GLOBIN —It is a curious proteid, it is coagulated by heat, soluble in dilute acids

HÆMATIN —It is deep brownish-red almost black crystals It contains all the iron of hæmoglobin, about 7 per cent, and can be oxidised and reduced It may occur in scaly masses with a metallic lustre

It is obtained by treating Hb with acetic acid in the presence of oxygen If HÆMATIN is treated with H_2SO_4 (Sulphuric acid) forms HÆMATOPORPHYRIN or iron-free hæmatin If hæmoglobin is treated with permanganate and nitrate, a pigment is formed called Methæmaglobin

HÆMIN

It is also a pigment which is not produced within the body, produced artificially by the decomposition of hæmoglobin It is the hydro-chloride of hæmatin, and occurs in

the form of minute black or reddish-brown prism or circular crystals Its production is used as a test for the presence of blood, as it is a sure sign of the presence of blood pigment, it does not contain iron It consists of Hcl and Hæmatin. If Hcl is added to hæmatin, it forms hydrochloride of hæmatin

HOW HÆMIN IS PREPARED

Place a drop of blood on a glass slide, together with a few crystals of common salt, a cover glass is put on, and a drop of glacial acetic acid introduced beneath it, and heat is gradually applied until bubbles appear On cooling dark-brown rhombic prism or plates make their appearance

It is a very important test of blood in Medico-legal work, in which stained object (cloth, wood, blotting-paper or earth) is extracted with dilute caustic potash afterwards treated in the same way as above

HÆMATOIDIN

It occurs in mahogany-coloured crystal tabular in form, and is found in old extravasation of blood It contains no iron, and has never yet been produced artificially It resembles bile-pigment, because it gives the same result in test

Fuming nitric acid gives a play of colour due to oxidative changes It is probably very nearly allied to (if not identical) the chief bile-pigment bilirubin, which behaves in a similar manner when treated with fuming nitric acid, though the composition of the bile pigment is probably not so complex as HÆMATOIDIN

OPTICAL CHARACTERS OF THE BLOOD

Blood flowing from the living body is of a bright scarlet colour when it comes from an artery, deep purple or almost black when it comes from a vein In thin layers it is transparent, in thick layers it is opaque, because the corpuscles act like *concave mirrors*, and the difference in the reflective power of the corpuscles and the plasma in which

they are suspended produces this opacity When blood is diluted it becomes more transparent

EXPERIMENT

Take two tubes containing equal quantity of blood in both Add in one water—becomes translucent. Add in the second common salt, becomes opaque

It is not simply due to dilution, but because the water causes the corpuscles to swell up and alters their refractive properties An equal quantity of a saturated solution of common salt does not cause a like transparency, as the corpuscles in this case do not swell up

COAGULATION

What do you understand of "coagulation?" It is the conversion of the fluid portion of the blood (liquæ sanguinis) into fibrin and serum, and the separation of the fibrin and corpuscles from the serum The fibrin passes from the soluble to the insoluble state

DESCRIPTION OF THE COAGULATION OF BLOOD

One of the most characteristic properties which the blood possesses is that of coagulating

The phenomenon may be observed when the blood as drawn from a living animal is at first fluid, it soon becomes viscid and is then rapidly converted into a jelly, this jelly being of the same as the pervious blood Then the jelly contracts, forming the clot, and a yellow clear liquid the serum oozes out The change begins first at the surface between the blood and the vessel, and slowly extends inwards The changes begin in about five minutes, and are complete in from one to several hours It ultimately separates into clot and serum The clotting of blood is due to the development in it of substance called fibrin

THE CLOT —Its upper surface is usually "cupped" It consists of a net-work of thin transparent threads of

"Fibrin" with the red corpuscles, in rouleaux, entangled in the meshes The upper part is a little lighter in colour

THE SERUM is pale yellow in colour, and at first contains no corpuscles, but by and by white corpuscles from the clot wander into it It contains no fibrin

PROPERTIES OF FIBRIN

Fibrin occurs to the extent of 0 2 per cent in the blood This substance can be obtained by stirring some freshly-drawn blood with a stick or bundle of twigs Then wash with water It is greyish-yellow fibrous, stringy, elastic body, insoluble in water or alcohol, soluble in alkalies, lactic, phosphoric and acetic acids Hydrochloric acid converts it into syntonin

If fibrin is heated with water, it is converted into coagulable proteid, so it belongs to proteid group

THE DIFFERENCE OF BLOOD CLOT BETWEEN HORSE'S BLOOD AND HUMAN

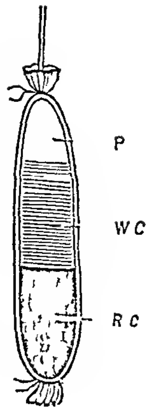
In horses' blood coagulation goes on more slowly, and the corpuscles have time to sink before the jelly stage is reached, so that a pale fawn stratum is formed on the top above the red clot, containing the white corpuscles This is called the "Buffy Coat" Further, the upper surface of the clot is very much more "cupped" than in the human blood clot The clot like horse's blood exists in human blood where there is "Local Inflammation," the buffed and cupped condition of the clot is well marked, because the tendency of the red corpuscles to form rouleaux is much exaggerated in inflammatory blood

CAUSE OF THE COAGULATION OF BLOOD

HEWSON'S EXPERIMENT

He ligatured both ends of one of the jugular veins of the horse, and cut out the part included between the ligatures, and allowed the blood settled by suspending it by one end. He found that the blood remained fluid for a long time.

The blood then separated into three layers, as —



1 The (R C) red corpuscles fall to the bottom

2 Above this white layer of white corpuscles (W C)

3 On the top of this again the Plasma P He drew off some of the plasma, and it soon coagulated He thus concluded that coagulation was due to a change in the plasma

BUCHANAN'S EXPERIMENT —

He added the serum of clotted blood to hydrocele fluid, and obtained a clot The same result was obtained by adding blood clot even after it had been washed He found that the upper part of the clot of horse's blood was more efficient than the lower Thus he concludes that white corpuscles are the cause of coagulation, that the cause, whatever it was, was derived from the white corpuscles He thought if we take some of the upper part of the plasma in Hewson's Vein experiment, it shows no special tendency to coagulate Take some of the lower part of plasma, there is a special tendency shown, because of the large number of white corpuscles in that part

Further, the fibrin appears first around the white corpuscles.

HAMMERSTAN'S THEORY —

That coagulation is due to the solidification of fibrinogen under the influence of the fibrin ferment It does not occur if the ferment be added to pure fibrinoplastin (Paroglobulin)

SCHMIDT'S THEORY —

That coagulation was the result of the interaction of fibrinogen and paroglobulin, brought about by the action of the "Fibrin Ferment" This theory is true to the extent that coagulation is due to a ferment—the "Fibrin Ferment"

PREPARATION AND CHARACTER OF THE FERMENT

This ferment can only be obtained from blood that has stood some time. It cannot be obtained when perfectly fresh blood is run from the blood-vessel of a living animal into alcohol

It is not present in normal living blood, but soon appears in shed blood, it is probably derived from the breaking down of the white corpuscles

Soak washed blood clot in an 8 per cent solution of sodium chloride, in this way we get a solution of the ferment

It may also be prepared from defibrinated blood by pouring it into about twenty times its bulk of alcohol, and allowing it to stand for about three weeks The alcohol coagulates all the proteids The fluid is then filtered off, and the residue dried and extracted with water, we thus obtain an aqueous solution of the ferment

ANOTHER FACT LENDS SUPPORT TO THE VIEW.

Ordinary lymph shows but little tendency to coagulate, but after it has passed through a lymphatic gland, it has a great tendency to coagulate, because many white corpuscles have been added to it Pericardial fluid also coagulates spontaneously when fresh, but wait for twenty-four hours before opening the pericardium and it does not coagulate, because the white corpuscles have disappeared from it Serous effusions, on the other hand, do not coagulate because they do not contain white corpuscles

PREPARATION OF FIBRINOGEN

This is best prepared from hydrocele fluid Dilute hydrocele fluid with ten or fifteen times its volume of water and pass a stream of CO_2 through it for a long time Add powdered common salt A sticky glutinous precipitate of Fibrinogen is obtained.

WHY THE BLOOD DOES NOT CLOT WITHIN THE VESSELS?

There seems to be some relation between the inner surface of the blood vessels and the contained blood, without the disturbance of which coagulation cannot take place, but if from any cause the inner surface of the vessel be injured or diseased, local clotting will ensue

When a needle is inserted into the wall of a vessel, a clot is formed round it, but the formation of the clot is preceded by an aggregation of colourless blood corpuscles round the needle It is probable by the disintegration of these that the "fibrin ferment" is set free, and coagulation results

COAGULATION IS ACCELERATED

(1) By contact with foreign substances of all kinds, but only when the blood adheres to them, hence thread or needles introduced into arteries are rapidly covered with fibrin (The coagulation always begins around the foreign body) Blood does not coagulate in contact with bodies covered with fat or vaseline The pathologically altered wall of a vessel acts like a foreign body

(2) Moderate heat 100° to 120° F

(3) Agitation of the blood, that is whip and stir it rapidly with a bundle of twigs, it coagulates very rapidly

(4) Free exposure to the air

(5) The addition of a small quantity of water

(6) Addition of calcium salt

(7) Also stasis of blood in the vessels, or injury to, or inflammation of, the vessel walls

CONDITIONS RETARD COAGULATION

(1) Temperature above 150° F

(2) If the whole mass is kept in constant uniform motion, it coagulates very slowly and imperfectly

(3) Cold, at a temperature below 40° F, and it will not coagulate at all, so also, if it be kept at the freezing point, it will not coagulate

(4) Saturation with neutral salt as magnesium sulphate or sodium chloride

(5) Contact with the living vascular walls

(6) In inflammatory states of the system it coagulates more slowly

(7) Contact with oil

(8) Addition of oxalates These precipitate the calcium necessary for coagulation as insoluble calcium oxalate

(9) Addition of leech extract

EFFECT OF GALVANIC ELECTRICITY ON BLOOD

AT THE POSITIVE POLE—the clot is hard, small, and firm, oxygen is set free, iron salts are produced, and the fluid round the needle has an acid re-action

AT THE NEGATIVE POLE—the clot is soft, loose, large, and frothy hydrogen is set free, and the fluid round the electrode has an alkaline reaction, caustic potash being produced

TRANSFUSION OF BLOOD

Human blood only should be used, because other kinds, *e g*, as from the sheep, break down and the stroma of the corpuscles block up the capillaries of the liver, leading to embolism and death

THERE ARE NUMEROUS METHODS OF TRANSFUSING HUMAN BLOOD

1 DIRECT TRANSFUSION FROM ARM TO ARM —For this many forms of apparatus have been used All that is necessary is a short piece of elastic tubing, at each end of which is a canula One canula is introduced and tied into a vein in the donor's arm, the tube being clamped The patient's vein is then opened, and the other canula is introduced into it after blood has been allowed to displace all air from the tube The flow is usually allowed to continue for about two minutes, but the pulses of patient and donor are carefully watched, so that the operation may be terminated when that of the patient is sufficiently improved

2 MEDIATE TRANSFUSION

Blood is drawn from a vein in the donor's arm to the extent of 10 or 12 ounces and is gently stirred with a fork for about five minutes (defilterated) It is then filtered through muslin into a funnel, whence it flows by a rubber tube and canula into a vein in the patient's arm

FATE OF TRANSFUSED BLOOD

After the transfusion of blood, the formation of lymph is greatly increased, but in one or two days the serum is used up, the water is excreted by the urine and the albumen is partly changed into urea Hence the blood at this time appears to be relatively richer in blood-corpuscles The red corpuscles break up much more slowly, and the products thereof are partly excreted as urea and partly as bile-pigments

SALINE TRANSFUSION.

This is the introduction of a warm saline solution to the circulation

THE GASES OF THE BLOOD

The gases of the blood are oxygen, carbonic acid, and nitrogen

LAW OF ABSORPTION OF GASES

1 ABSORPTION BY SOLID BODIES —A considerable attraction exists between the particles of solid porous bodies and gases, whereby the latter are attracted and condensed within the pores of solid bodies, *i e*, the gases are absorbed Heat is always formed when gases are absorbed Non-porous bodies are similarly invested by a layer of condensed gases on their surface

2. ABSORPTION BY FLUID —Fluid can also absorb gases A known quantity of fluid at different pressures always absorbs the same volume of gas When a fluid, *e g*, water, is exposed to any gas or mixture of gases, the gases will either escape from the liquid or be absorbed by it until equilibrium is established between the pressure of gases in

the atmosphere above and the tension of gases in the water below This is the case with every individual gas, no matter how many may be present in the mixture, the absorption or escape of any one is independent of the presence of others The absorption of any gas, therefore, by a liquid, depends on the "partial pressure" of that gas in the atmosphere to which the liquid is exposed The pressure is called "partial," because the pressure of any one gas only forms a part of the general pressure

As oxygen forms one-fifth of the atmosphere of which the total is 30 inches of mercury, therefore the "partial" pressure of oxygen in the atmosphere is one-fifth of 30=6 inches The gases of blood are extracted by means of the Mercurial Gas Pump of Pfluger

THE PERCENTAGE OF THE BLOOD GASES

100 volumes of blood contain 60 volumes of gas

	O	CO_2	N
Arterial	20	39	1 to 2
Venous	8 to 12	46	1 to 2

1 OXYGEN IN THE BLOOD IS HELD—Almost the whole of the oxygen of the blood is in loose chemical combination with the hæmoglobin in the corpuscles, only a very small proportion is simply dissolved The proof of the fact is that the oxygen of oxyhæmoglobin can be replaced by equivalent quantities of other gases, like carbonic oxide All the respiratory oxygen is removed by a vacuum

If you shake the arterial blood in the air, it becomes venous, because O is given off, therefore it is in loose combination This does not occur with venous blood

CARBONIC ACID STORED IN THE BLOOD

It is nearly all contained in the serum The serum yields almost as much carbonic acid as the serum plus corpuscles It is partly absorbed by the water of the serum, but chiefly in chemical combination Part is

firmly combined as Sodic Carbonate, and more loosely combined with this to form the bi-carbonate, a small part also is united with Sodium Phosphate The sodium compounds are the chief carriers of carbonic acid from the tissues to the lungs Volume for volume serum yields as much carbonic acid as blood

Nitrogen is retained in the blood It is simply dissolved in the water of the blood, it has no physiological importance

ANALYSES OF BLOOD-GASES

1 First shake up the gas in the test-tube with Caustic Potash, this absorbs all the carbonic acid

2 Then add Pyrogallic acid, and this absorbs all the oxygen

3 The remainder presents the volume of nitrogen

ARTERIAL AND VENOUS BLOOD

Arterial blood contains in solution all those substances which are necessary for the nutrition of the tissues, those which are employed in secretion, and it also contains a rich supply of O and a considerable amount of CO_2

Venous blood contains less of the nutrient matter, but in addition it holds the used-up or effete substances derived from the tissues, and the products of their retrogressive metabolism are more numerous, there is in venous blood a larger amount of CO_2, and also a considerable amount of O

CHAPTER II.

CIRCULATION

BRIEF SUMMARY OF THE CIRCULATION

THE blood is contained during life in a continuous system of more or less elastic and contractile vessels These are (1) the *arteries,* ending in (2) the *capillaries,* from which originate the (3) *veins,* the special contractile organ of the *Heart* We must also consider here the *Lymphatics,* which are vessels that convey back the lymph (the fluid which exudes through the thin walls of the blood-capillaries) to the large veins near to their entrance into the heart, and the large lymph spaces contained in the *serous membrane* The blood is in a state of continual motion It is carried from ventricles by the large arteries (aorta and pulmonary), and their branches to the system of capillary vessels, from which again it passes into the veins that end in the auricles The heart may be regarded as a double organ, each half consisting of an auricle and a ventricle The

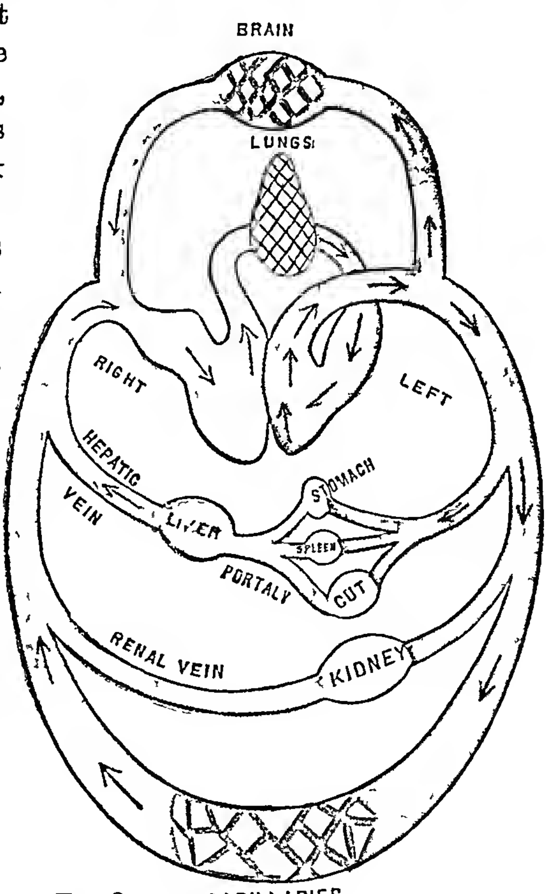


Fig 3

right half contains blood which has been returned from the body to be sent to the lungs The left half contains blood which has been returned from the lungs to be distributed to the body The heart is beating regularly, acting both as a force pump and as a suction pump, in other words, the heart is recipient body as well as propeller

There are thus two circulations,—*Systemic* or *greater* and *Pulmonary* or *lesser*

(1) THE GREATER OR SYSTEMIC CIRCULATION

This includes the course of blood from the left auricle and left ventricle through the aorta and all its branches, the capillaries of the body and the veins, until the two vena cava end in the right auricle

(2) THE LESSER OR PULMONARY circulation which includes the course of the blood from the right auricle and the right ventricle by the pulmonary artery to the lungs through the pulmonary capillaries of the lungs and back by the pulmonary veins springing from them to the left auricle

PERICARDIUM

It is placed in the middle mediastinum of the chest It is a closed cavity, the heart being pushed in, invaginating it Its base is attached to the central tendon of the diaphragm, wall of the œsofagus and the pleuræ It is a fibro-serous membrane, and projects most to the left side

FIBROUS LAYER

This is the external layer, and consists of strong interlacing fibrous tissue It is continued upon the large blood-vessels for some distance as tubular prolongations, which are gradually lost upon their coats It keeps the heart from rocking about too much

THE SEROUS LAYER

This is the internal layer, and lines the fibrous part of the pericardium, and is then reflected over the heart It

encloses the aorta and the pulmonary artery in a common sheath Each of the great veins has its own investment, though that to the inferior vena cava is very short The function is to allow the heart to move readily It consists of a single layer of squamous epithelium

HEART

ANATOMY —The heart is in shape like a blunt cone, the base points upwards, backwards, and to the right, opposite the fourth to the eighth dorsal vertebræ The apex is directed downwards, forwards, and to the left between the fifth and sixth ribs It has four openings following —

(1) The pulmonary artery, (2) the aorta, (3) left auriculo-ventricular opening, (4) right auriculo-ventricular opening

HISTOLOGY

The heart is a hollow muscle, and consists of special variety of muscular fibres and fibrous rings for their attachment

FIBROUS RINGS

They are four in number, and surround the right and left auriculo-ventricular orifices, the aorta and the pulmonary artery The fibrous tissue is continuous with that in the segments of the valves, and also serves for the attachment of the muscular fibres Those of the aortic and left auriculo-ventricular openings are close together

MUSCULAR FIBRES —The muscular fibres are of an irregularly cubical form, faintly streaked transversely, and destitute of sarcolemma, frequently having bands at the broad ends by which they anastamose, and showing an oval nucleus The muscular fibres of the auricles are distinct from those of the ventricles

FIBRES OF AURICLES

They consist of a superficial set common to both, and a deep set proper to each

SUPERFICIAL SET

They pass round both auricles in a transverse direction

DEEP FIBRES —They consist of two sets of fibres —(1)

The looped, which pass over each auricle, and are fixed to the corresponding auriculo-ventricular rings

(2) The auricular, which encircle the appendices and are continued upon the vessels opening into it, and form rings around These rings around the venous openings act as sphincter

VENTRICULAR FIBRES

They consist of many layers The outer and inner layers are especially well marked The apex of the heart is formed exclusively by the first (outer) and the seventh (inner) layer

THE CHAMBERS OF THE HEART

The interior of the heart is divided into two chief chambers or cavities—right and left Each of these is again subdivided transversely into AURICLE and VENTRICLE

THE RIGHT AURICLE

It consists of sinus and auricular appendix, it contains about 2 ounces It has the following openings into it —

(1) Superior vena cava—No valves

(2) Inferior vena cava—Imperfect valve

(3) Coronary sinus—Perfect valve

(4) The auriculo-ventricular, the opening into the right ventricle, it admits three fingers

The valve of inferior vena cava —It is called "Eustachian valve" It is a cresentic fold of the lining membrane in front of the opening of the inferior vena cava It is an imperfect valve

The valve of the Coronary sinus is called the valve of Thebesius it is the only vein of the heart that has a perfectly closing valve

THE RIGHT VENTRICLE

It forms about two-thirds of the anterior surface of the heart It is crescentic in form, as the septum between it and the left ventricle bulges in Its walls are much thinner than the left It takes no part in the formation of the apex It has the following openings —

(1) The auriculo-ventricular, guarded BY THE TRICUSPID valve, it has three segments or cusps to this valve, hence the name

(2) The pulmonary artery springs from the conus arteriosus, and is guarded BY THE SEMI-LUNAR VALVES There are strings attached to the valves called "CHORDÆ TENDINEÆ" and are attached to the ventricular surface, and come from the musculi papillares The inner surface of the ventricle is marked by projection of the muscular bundles called Columnæ Carnæ

THE LEFT AURICLE

It resembles the right auricle The appendix overlaps the root of the pulmonary artery, and the only part of the auricle seen from the front The musculi pectinati are fewer than those of in the right It has the following openings —

(1) The four pulmonary veins and have no valves

(2) The auriculo-ventricular —This is smaller than the corresponding opening on the right side, and only admits two fingers

THE LEFT VENTRICLE

It is chiefly situated behind It is oval or round on section, and its walls are about three times as thicker as the walls of the right The columnæ corneæ are smaller and numerous The musculi papillares are collected into two groups It has the following openings —

(1) The auriculo-ventricular, guarded by the mitral or bi-cuspid valve

(2) The aortic, guarded by the semi-lunar valve

WHY THE WALLS OF THE LEFT VENTRICLE ARE THICKER THAN THOSE OF THE RIGHT?

Because the thick-walled left ventricle has to carry on the systemic or greater circulation, driving the blood through all parts of the body The thin-walled right ventricle has only to carry on the pulmonary or lesser circulation, only driving the blood through the lungs

USES OF THE MUSCULI PAPILLARES AND THE CHORDÆ TENDINEÆ

The chordæ tendineæ spring from the ends of the musculi papillares, and pass to be attached to the segments of the auriculo-ventricular valves When the heart contracts, the musculi shorten at the same time, and this keeps the chordæ tense, notwithstanding the contraction of the ventricles, and in this way the segments of the auriculo-ventricular valves are kept from being forced back into the auricles and thus regurgitation is prevented

NOTE —In regard to the auricles that the contraction begins at the venous openings In the case of the pulmonary veins, it begins at the root of the lungs, and in this way there is no need of valves for the venous openings

THE "VALVES"

The valves are double folds of the endocardium, enclosing fibrous tissue, continuous with and attached to that of the rings The valves prevent the blood from passing back into the ventricles, and the tricuspid and mitral which protect the auricles from the same result

THE RIGHT AURICULO-VENTRICULAR VALVE OR TRICUSPID

It is called the Tricuspid, because it consists of three cusps or segments The cusps are placed anterior, posterior, and left, the left is the largest, the valves are thicker in the centre, but thin at the edges The convex margin is attached to the fibrous rings The auricular surface is smooth, but the ventricular surface is rough The roughness is due to the attachment of the chordæ tendineæ The chordæ tendineæ are attached to the musculi papillares and to the margin of the valve The chordæ tendineæ prevents the flap from being carried back into the auricle during the pressure produced by the contraction of the ventricle, the musculi papillares keep them tight

Tricuspid has "safety valve action" It means that regurgitation takes place normally at this valve It closes

less perfectly than the mitral, and a little blood is driven back into the right auricle, producing slight regurgitant flow and venous pulse a little way into the innominate veins In ordinary cases the pulse does not pass further because of the valves But should the tricuspid valve be diseased, the pulsation may pass into the internal and external jugular veins

The use of "safety valve" action is that it prevents over-distension of right ventricle This is of great importance, because if the heart be over-distended, sudden paralysis is apt to occur

MITRAL OR BICUSPID VALVE

It has only two segments and smooth on both sides Because along one surface the blood from the auricle passes, while close beside the other, the blood makes its exit at the aortic orifice The valve normally completely closes the opening, and does not allow of any regurgitation It is, however, often diseased

SEMILUNAR OR SIGMOID VALVE

These valves are placed at the aortic and pulmonary orifices Each has three cusps, and about the middle there is a slight cartilaginous thickening known as the Corpus Arantii Above the valve segments there are three small pouches called "Sinus of Valsalva" The uses of the sinus of valsalva are that they allow an eddy stream round the valve segments, and thus support them against the axial stream, they are thus prevented from sticking to the walls of the vessel, and the blood in the sinus also helps to close them during DIASTOLE The blood in its regurgitation towards the heart finds its way into the sinus, and so cause the flaps of the valve to close

THE ENDOCARDIUM

It is a serous membrane, lining the interior of the heart. It consists of connective tissue, elastic fibres, and Purkinje's fibres with a layer of endothelium on the free surface There may also be a few non-striped muscular fibres

The valves are prolongation of the endocardium It is directly continuous with the internal lining of the arteries and veins

MOVEMENTS OF THE HEART

It is also called Cardiac Cycle The movements of the heart is characterised by an ALTERNATE CONTRACTION and RELAXATION OF ITS WALLS The period of contraction is called the SYSTOLE and that of relaxation the DIASTOLE The total cardiac movement is called CARDIAC CYCLE

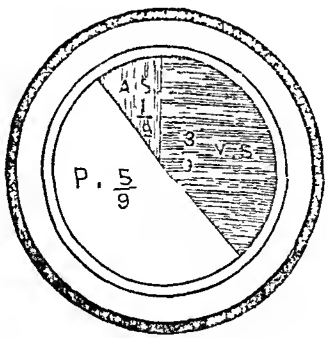
It consists of THREE ACTS—the contraction, (1) or systole of the auricles—the contraction or systole of the ventricles—and (2) the PAUSE During the pause the auricles and ventricles are (3) relaxed During the contraction of the auricles, the ventricles are at rest, whilst during the contraction of the ventricles the auricles are relaxed The rest during the phase of relaxation is called the DIASTOLE

The three events of cardiac cycle are—

(1) Auricular systole = one-ninth of the whole

(2) Ventricular systole = three-ninths of the whole

(3) Pause = five-ninths of the whole



A S $\frac{1}{9}$ = Auricular systole
V S $\frac{3}{9}$ = Ventricular systole
P $\frac{5}{9}$ = Pause

THE FOLLOWING IS THE SEQUENCE OF EVENTS IN THE HEART DURING A CARDIAC CYCLE

1 PAUSE —During the pause the blood is flowing into both auricles and ventricles, from the venæ cavæ,

and the heart is being dilated This dilatation acts like a suction pump, and the blood rushes towards the heart

2 AURICULAR SYSTOLE —The ventricles are partly and the auricles completely filled, and then the sharp sudden auricular systole takes place In this case the contraction begins in the veins, and runs towards the auricles in a peristaltic wave, and in the direction of the auriculo-ventricular orifices

3 VENTRICULAR SYSTOLE —The ventricles are now turgid and completely dilated, and the auriculo-ventricular valves closed by the first effort at the contraction on the part of the ventricles, and then the continued contraction forces the blood out at the pulmonary and aortic orifices The heart then begins to dilate, and the aortic and pulmonary semilunar valves once more closed, and thus the cycle begins again

THE CHANGES IN THE SHAPE AND POSITION OF THE VENTRICLES DURING CONTRACTION

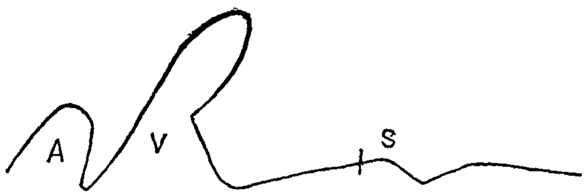
The ventricles become shorter, thicker, and feel tense and hard, and the base of the heart approaches the apex The apex twists a little and moves from the left and behind to the front and right The aorta and pulmonary artery expands and elongates During diastole this state of affairs is reversed The apex does not change place in vertical direction, because the shortening of the ventricles is compensated by the lengthening of the great arteries The base of the left ventricle during contraction becomes circular from eliptical

It is proved by means of three pins If three pins inserted through the chest wall into the apex, middle and base of the ventricles, are carefully watched during the beats of the heart, the heads of those pins will be seen, respectively, that of the first one, the lower, merely to quiver, that of the second one to incline slightly upwards, and that of the third one to incline upwards a good deal

more This shows that the apex of the heart does not move in the vertical direction, but that the base moves downwards and towards the apex

MAREY'S METHOD OF RECORDING THE HEART'S MOVEMENT

In the case of the horse a cardiograph is applied to the chest wall, small elastic bags communicating with separate tambours introduced through the internal jugular vein into the right auricle and right ventricle The movements are recorded by the ordinary apparatus



A=auricular, V=ventricular
S=sigmoid

APEX-BEAT OR CARDIAC IMPULSE

By the term apex-beat is meant under the normal condition an impulse which is perceptible to touch and sight in a circumscribed area of the fifth left intercostal space two inches below the nipple, and caused by the movement of the heart It is synchronous with the systole

CAUSES OF THE IMPULSE

1 It is due to the sudden onset of hardness of the substance of the ventricle against the chest wall

2 To a tilting forwards of the apex in a screw-like manner, due to the spiral arrangement of the superficial fibres of the ventricles, it rotates from the left and behind to the front and right at the time of systole It is the twisting motion that gives the impulse

3 Another possible cause is the tendency of the aorta to straighten itself owing to the discharge of blood into it, whereby the apex is pushed downwards and forwards

ENDOCARDIAL PRESSURE

"It is measured by a mercurial monometer The pressure in the ventricles is positive +, and therefore the fluid tends to escape This pressure in the left ventricle of a dog during systole will rise a column of mercury, 1 inch in diameter, $5\frac{1}{2}$ inches In the right ventricle it is about 2 inches During diastole or immediately after systole the pressure is minus or negative in both auricles and ventricles, which thus acts the part of a suction pump, *i e*, the pressure there being less than that of the atmosphere, the atmospheric pressure forces the blood towards it The pressure in the left ventricle may be one-fifth of an inch below that of the atmosphere Part of the 'negative pressure' may be due to respiration, but the great cause is the elasticity of the ventricles The negative pressure is most marked in the left ventricle The heart thus acts both as a 'force' pump, and as a 'suction' pump, helping to refill itself This 'suction action' of the left ventricle is specially useful in helping the circulation through the lungs The pressure can be obtained by C-shaped monometer"

THE HEART SOUNDS

On listening over the region of the heart in a healthy man, either by means of a stethoscope or with the ear applied directly to the chest wall, we hear two sounds pronouncing to the ear the syllables *Lŭpp dŭpp* The two sounds are called *first* and *second*, they follow each other in quick succession, and are followed by a pause Thus

At apex—*Lŭpp dŭpp* (pause) *Lŭpp dŭpp*
At base—*Lŭpp dŭpp* (pause) *Lŭpp dŭpp*

THE FIRST SOUND (long or systolic) —It is long, deep, dull, and booming, and coincides with the cardiac impulse and just precedes the pulse, and is synchronous with the systole of the ventricles—thus named Systolic

THE TIME OF THE FIRST SOUND CORRESPONDS to the contraction of the ventricles, the closure of the auriculo-ventricular valves, the opening of the semi-lunar

valves, and the projection of blood into the arteries and impulse of apex against the chest It ends shortly before the ventricles begin to relax

THE CAUSE OF FIRST SOUND.

1 Its chief cause is the stretching and vibration of the auriculo-ventricular valves, and it disappears to a large extent as the heart becomes empty

2 There is another cause which is supposed to be a probable cause The "muscle sound" produced by the contraction of the muscular fibres of the heart itself

WHERE THE FIRST SOUND IS BEST HEARD?

It is best heard at the apex in the fifth intercostal space of the left side, two inches below and one to the inner of the nipple Because the mitral valve produces the greater part of this sound, and the blood flowing from the left ventricle carries the sound towards the apex

THE SECOND SOUND—or Diastolic It is shorter, sharper, clearer, higher in tone, more sudden than the first sound It is synchronous with closure of the semi-lunar valves It marks the beginning of the ventricular diastole—thus named Diastolic

THE TIME CORRESPONDS

(1) Closure of the semi-lunar valves from elastic recoil of the aorta and pulmonary artery, (2) relaxation of ventricular walls, (3) opening of the auriculo-ventricular valves so as to allow the passage of blood from the auricle to ventricle

THE CAUSE OF THE SECOND SOUND

It is due to the sudden tension and stretching of the fibres of the aortic and pulmonary semi-lunar valves as they are closed If the segments be hooked up, the sound stops Therefore this is believed to be the only cause

WHERE SECOND SOUND IS HEARD LOUDEST?

At the base of the heart in the second intercostal space, as the aorta comes nearest the surface and the aortic valve

produces the greater part of the sound, therefore the sound is best heard there

PULMONARY VALVE SOUND BEST HEARD

It is heard best between the second and third left costal cartilages, because at this point the pulmonary orifice is the most anterior and nearest the surface of the chest wall

TRICUSPID VALVE SOUND BEST HEARD

It is heard best at the left side of the ensiform cartilage, or behind left half of sternum from fourth to fifth cartilage, because the blood stream from the right auricle conducts the sound in that direction here, therefore, murmurs are best heard

THE TIME CORRESPONDS WITH PAUSE —(1) The gradual refilling of the ventricle from the auricle and (2) contraction of the auricle, so as to entirely fill the ventricle

INFLUENCE OF THE RESPIRATORY PRESSURE ON THE HEART

The variation in pressure owing to the increase and decrease in the size of the chest caused by respiratory movement exerts an influence on the movement of the heart

The diastolic dilatation of the cavities of the heart is chiefly caused by the elastic traction of the lungs It is also caused by the pressure of the venous blood and the elastic stretching of the relaxed muscle wall

In normal respiration the air in the lungs during inspiration is under slight pressure, while during expiration the pressure is higher, so that these conditions favour the circulation

Inspiration favours occurrence of diastole and flow of blood through venæ cavæ

Expiration favours the flow of blood in the aorta and its branches, and aids systolic emptying of the heart.

The elastic traction of the lungs aids the pulmonary circulation The blood of pulmonary capillaries is exposed to the pressure of the air in the lungs, while the blood in the pulmonary veins is exposed to a less pressure, as the elastic traction of the lungs, by dilating the left auricle, favours the outflow from the capillaries into the left auricle Thus inspiration always favours the venous stream and hinders the arterial, while expiration hinders the venous and favours the arterial stream.

INNERVATION OF THE HEART

"It has been known from early times that when the heart is removed from the body, or when all the nerves which pass to it are divided, it still beats for some time Even after the heart has ceased beating, it may again be caused to contract by direct stimulation or by heat The injection of arterial blood into the coronary vessels will restore excitability in the heart after it has ceased to beat (Ludwig), so that its movements must depend upon some mechanism situated within the heart Therefore the nerve mechanism is divided into INTRA-CARDIAC and EXTRA-CARDIAC"

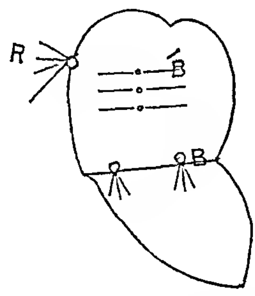
INTRA-CARDIAC

This has been investigated more especially in the heart of the frog The automatic beat of the heart is due to the presence of ganglia The nerves lying in the grooves of the heart and its substance contain numerous ganglia This is automatic motor centres for the heart

BIDDER'S GANGLIA

Are situated into auriculo-ventricular sulcus of the frog's heart

They are motor centres for the ventricle



Frog's Heart
B = Bidder's ganglia
B́ = Bezold's
R = Remak's.

DESCARTE'S EXPERIMENT

He separated the ventricle from the auricles by an incision on the auricular side of Bidder's ganglia, and observed on the movements of the heart He found both auricles and ventricles go on beating, but the ventricles more slowly than the auricles From this it is assumed that the ventricular ganglia can act independently, but appear to be more sluggish than the auricular ganglia

STANNIUS' EXPERIMENT

It consists of two parts —

He first cut off the sinus venosus from the frog's heart with the ganglia of REMAK'S from the auricles The effect was that the sinus continues to beat, but the auricles and ventricles remain at rest

The second part of his experiment was to cut off the ventricle with BIDDER'S GANGLIA from the auricles

He noticed that the ventricle resumed its beating, but the auricles remained at rest, although they still contain ganglia, viz, those of the auricular septum

BEZOLD'S AND TROUB'S EXPLANATION —

They hold that the ganglia of Bidder and Remak are both motor, but that Remak's are the more excitable and initiate the events of the cardiac cycle That the ganglia in the auricular septum are probably inhibitory, though they are unable to inhibit Remak's ganglia, unless aided by the inhibitory influence of the vagus, but that when the ganglia of Remak are removed, they can completely inhibit the ventricular ganglia, as shown by the first part of the experiment of Stannius, and further that when the ventricle with its ganglia is removed from the influence of the inhibitory ganglia of the auricles, it again begins to beat, as shown by the second part of the experiment of Stannius

EXTRA-CARDIAC NERVES

There are the cardiac plexus outside the heart, and no doubt communicate with the intra-cardiac ganglia These

nerves are derived from the cardiac branches of the sympathetics and vagi There are two sets of plexus —

1 SUPERFICIAL CARDIAC PLEXUS

It is formed by branches from the left superior cervical ganglion of the sympathetic with the inferior cardiac branch of the left vagus, together with twigs from the deep plexus

It lies in the concavity of the arch of the aorta in front of the right branch of the pulmonary artery In it we find the ganglion of Wrisberg It gives off the anterior coronary plexus

2. DEEP PLEXUS

It is formed by all the other cardiac branches of the sympathetics and vagi, together with branches from the superficial plexus

The Cardiac branches of vagus —
The Inferior Cardiac
The Superior Cardiac

THE FUNCTION OF THE INFERIOR CARDIAC

The inferior cardiac is the inhibitory nerve of the heart *N B* —(Note the two I's—Inferior—Inhibitory)

THE EFFECT OF CUTTING THIS NERVE

The heart beats more rapidly, as the impulses sent from the brain through this nerve to inhibit the heart's action no longer, of course, reach the heart, and, therefore, since restraining power is cut off, the heart beats faster The same effect will be produced by cutting the vagi in the neck, as this cuts the fibres conveying the impulses down the cord from the brain

THE EFFECTS OF STIMULATING THE CUT END

(1) Stimulate the lower end—
  (*a*) Gently the heart is again inhibited
  (*b*) More strongly the heart is slowed or stopped, as the inhibitory power so much increased

(2) Stimulate the upper end—no effect

THE CONDITION OF THE HEART WHEN STOPPED BY STIMULATION OF THE INHIBITORY NERVE

If stopped by stimulation of the lower end of the cut inferior cardiac branch of the vagus, it swells up and is brought to a state of repose in diastole. The effect produced by the influence exerted on the cardiac ganglia, NOT from any effect on the muscular fibres Because if the muscle of the heart be stimulated during this period, the ventricles contract as usual

The cardiac-inhibitory fibres are not found in the vagus at its superficial origin on the surface of the brain They are found in the spinal accessory nerve, and enter the vagus with the large root of that nerve near the base of the brain It is proved if you cut the spinal accessory at its root, and the heart beats more rapidly, just as when the vagi are cut in the neck

The cardio-inhibitory mechanism is always in action It is believed on the fact that when the vagi are cut in the neck, the heart always beats faster

THE SUPERIOR CARDIAC BRANCHES OF THE VAGUS

They perform their own action as the SENSORY nerves of the heart

N B —(Note the two S's—Superior—Sensory) They take their origin from the upper and lower parts of the cervical portion of the vagus with two roots below the superior laryngeal nerve There are no effects on the heart on cutting the nerves, nor any effect on the heart on stimulating the lower end of the divided nerve

THE RESULT OF STIMULATING THE UPPER END THUS —

1 Pain is felt, as it is a sensory nerve

2 The cardio-inhibitory centre is excited, and the heart, therefore, slowed, with a consequent slight fall in the blood pressure, because the force of propulsion is diminished

3. There is marked reflex dilatation of the abdominal blood vessels, with consequent great lowering of the systemic arterial pressure

It is believed that the nerve probably contains vaso-inhibitory fibres as well as sensory, and the stimulation thus inhibits the vaso-motor centre This centre is always in a state of activity, but the stimulation lessens its activity, and retards its evolution of energy, and hence the dilatation of the blood-vessels of the abdomen, as the cells specially affected are those that preside over that large vascular area

This nerve is called "Depressor," as it lowers the blood pressure, and it is not in constant action

The special points to note about the nerve are the following —

1 It is sensory nerve to the heart

2 It seems to contain fibres that can affect the cardio-inhibitory centre, stimulating it and slowing the heart

3 It contains vaso-inhibitory fibres that affect the vaso-motor centre in the medulla, or that part that presides over the blood vessels of the abdomen, and thus causes dilatation of these vessels.

CARDIO-INHIBITORY CENTRE

The centre is placed in the medulla, and it is automatic in its action

THE FOLLOWING CONDITIONS MAY AFFECT THE ACTIVITY OF THE CARDIO-INHIBITORY CENTRE

1 Stimulation of ordinary sensory nerves may increase its activity and slow the heart

2 Increase of blood pressure in the brain increases its activity, and thus slows the heart, and allows the blood pressure to fall again as thus—

Clamp the abdominal aorta when the pressure in the brain is much increased, and the heart slowed, but if the

vagi are previously divided, this effect on the heart is not observed

3 Retard respiration so as to produce a venous condition of the blood, excites the centre and retards the heart

4 Emotion, whether of joy or sorrow, may fatally inhibit the heart by exciting cardio-inhibitory centre

CARDIAC BRANCHES OF SYMPATHETIC GANGLIA

They arise in a cardio-motor centre in the medulla The fibres pass down from the medulla, and then leave the cord by the second and third dorsal nerves, and enter into the first and second sympathetic ganglia, and thence to inferior cervical ganglion, and pass from this to the heart as NERVE ACCELERANS This nerve is not in constant action It is proved by, when nerve is divided, no change is observed in the movements of the heart When the peripheral end of the divided nerve is stimulated, the heart is accelerated This nerve and centre are usually excited by emotion and by reflex influences, as from an irritable state of the stomach, causing palpitation

WHY DOES THE HEART BEAT FASTER WHEN ONE WALKS FAST OR RUNS?

On account of the muscular effort, more venous blood is brought to the heart in a given time, its temperature is also slightly raised In this way the *endocardium* is stimulated by the blood, and thus the ganglia are affected and discharge their energy faster, and hence the increased activity It is probable that this stimulation of the endocardium by means of the blood is the chief cause of the so-called automatic discharge of energy by the intra-cardiac ganglia At the same time the heart's action is essentially automatic, though it can thus be affected by influences from without, *e g*, as from the brain, by emotion, &c

N B—RESUMÆ

1 Sympathetic nerves "Nerves Accelerans" is not aways in a state of activity

2 The superior cardiac branch of the vagus "Depressors" is sensory, and is not always in a state of activity

3 That the inferior cardiac branch of the vagus is inhibitory, and is constantly in a state of activity

Further, that the heart has three sets of nerves, and each of them perform their own action

1 From the ganglia in its wall

Function—for the usual regular rhythmic movement

2 The vagus—superior and inferior—function—the former is sensory and the latter cardio-inhibitory

3 Sympathetic—function—cardio-motor

THE OTHER CONDITIONS THAT AFFECT THE HEART'S ACTION

1 *Temperature*—Heat tends to quicken, and cold to slow the heart's motion.

2 *Blood Pressure*—Heart is retarded, when venous blood returns to the heart quickly, then the heart beats faster

3 *Muscular Exertion*—Quickens the heart's action in two ways —(1) by quickening the venous return to the right auricle, (2) by raising the temperature of the blood

4 *Atmospheric Pressure*—At the top of a mountain it is quickened, at the bottom of a mine, slowed

5 *Position of the Body*—Most rapid in the erect posture, slowest in the recumbent

6 *Age and Sex*—Fastest in young children, less so in adults—fœtus in utero, 140 per minute, adult female 75 to 80, adult male 70 per minute

THE RISKS OF MUSCULAR EXERTION IN THE FEEBLE HEART

The muscular exertion is dangerous to the weak heart, as it may produce fatal result due to failure of the heart in the following way —

(1) By increasing the resistance to the outflow from the left ventricle

(2) By hastening the venous return to the right side of the heart, so that the heart is unable to expel fast enough In both cases the corresponding ventricle becomes over-distended and paralysed

THE EFFECT OF VARIOUS DRUGS

1 Pilocarpine and muscarine and calabar bean stimulate the cardio-inhibitory mechanism, so the heart is slowed

2 Atropin, hyoscyamin, and daturin, paralyse the cardio-inhibitory mechanism Atropine antagonises the action of calabar bean and pilocarpine

THE EFFECT OF DIGITALIS ON THE HEART

It increases the force of contractions of the ventricles, not the auricles The big dose will stop the ventricles in a state of spasm, while the auricles still go on beating

CLINICAL EXAMINATION OF THE HEART

For the clinical convenient heart is divided into base, apex, right border, left border, inferior border, and into four areas—mitral, tricuspid, aortic, pulmonary

BASE—is found by right auricle, and its appendix and conus arteries at its junction with pulmonary artery

APEX—reaches the fifth left intercostal space

RIGHT BORDER—formed by right auricle, extends $1\frac{1}{2}$ to 2 inches to right of midsternal line

LEFT BORDER—formed by left ventricle, extends $3\frac{1}{4}$ to $3\frac{3}{4}$ inches to left of mid-sternal line.

INFERIOR BORDER—formed by right ventricle, and a small portion of left ventricle from fifth or sixth costal cartilages at junction with sternum to apex

THE PHYSICAL EXAMINATION —

INSPECTION —Note—is there any bulging movement of apex-beat, pulsation in epigastrium, pulsation in the neck or other region

PALPITATION—determine the position of apex beat, note the diffusion of the apex beat, note the force and character

PERCUSSION —Make out the different borders of the heart

AUSCULTATION —This is one of the most valuable methods by which we can detect variations and modifications in the healthy sounds of the heart The existence of abnormal sounds and their exact relation to the normal sounds, and the direction in which these sounds are propagated, have to be made out

First sound marks beginning of systole Systole continues through nearly the whole of short pause

Second sound marks the beginning of diastole Diastole continues through nearly the whole of long pause

The learners must familiarize themselves at first with the normal sounds before they enter to study the "Murmurs of the Heart"

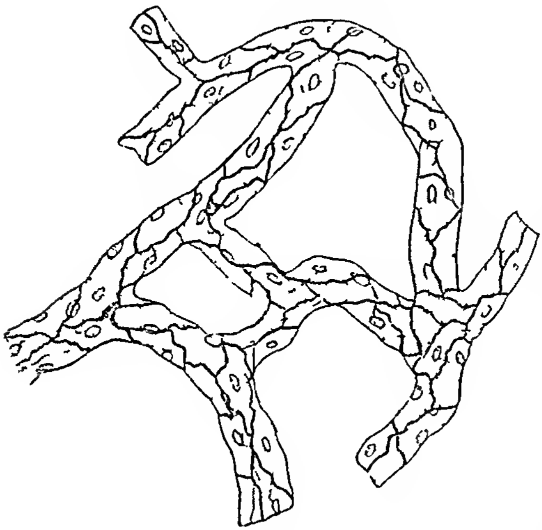
CHAPTER III.

BLOOD VESSELS.

HISTOLOGY

STRUCTURE OF THE CAPILLARIES

They usually consist of tubes formed of a layer of squamous endothelium, the edges of the cells are very tortuous In the cement substance between the cells, here and there minute dots or little apertures may be seen during distension, these are called STOMATA, and it is through these apertures that diapedesis occurs The cells are elastic, and are capable of altering their shape There is no muscular coat The size, form, diameter vary in the different tissues of the body



THE STRUCTURE OF ARTERY

The artery has three coats—

(1) Internal or tunica intima
(2) Middle or tunica media
(3) External or tunica adventitia

THE INTERNAL COAT

It consists of three layers, and can be readily stripped off the inner surface of the artery as a transparent, colourless elastic and very brittle membrane Its layers are —

(1) An endothelial lining, consisting of a single layer of thin elongated cells with nuclei

(2) A layer of sub-endothelial connective tissue, consisting of white fibres and delicate stellate connective tissue corpuscles

(3) *The Elastic Lamina* —This forms the chief thickness of the inner coat, and is formed by several strata It consists of yellow elastic fibres in the form of A MEMBRANE called "fenestrated membrane of Henli", it is homogeneous or perforated, and marked with longitudinal pale streaks When stripped off, the ends curl up The internal coat is very brittle

THE MIDDLE COAT

It consists chiefly of layers of non-striped muscular fibres arranged in a circular manner It also contains some white and yellow fibrous tissue mixed with the muscular bundles This is also very brittle

It varies in different arteries As for example in passing from the larger to the smaller arteries, the muscular part increases in thickness But in passing from the smaller to the larger there is more and more elastic tissue, *e g* , in the first part of the aorta the proportion of elastic to muscular tissue is very much increased

EXTERNAL COAT

It consists chiefly of longitudinal bundles of white connective tissue with some elastic fibres mixed with them This coat is very tough and resistant The peculiarities in regard to the structure of arteries are —

In the renal, carotids and mesenteric there is an external elastic lamina, and in these, therefore, the muscular coat is enclosed between elastic lamina The arteries in the cavity of the cranium and spinal canal have thinner coats in proportion to their size than ordinary arteries This is due to thinness of the external and middle coats

If we trace the arterioles down to capillaries, the elastic elements, outer and middle coats, disappear The elasticity

of arterioles are more marked in larger arteries, *e g.*, in aorta, the contractibility is more marked in smaller arteries

THE STRUCTURE OF VEINS

They resemble arteries in structure, only their coats are thinner, and they collapse when cut, and their lumen are wider than the lumen of corresponding arteries The walls are thinner on account of smaller amount of muscular and elastic tissues, but contain more white fibrous tissues The outer coat is thicker The veins contain valves The valves consist of semi-lunar folds of the internal coat with some connective tissue The valves prevent reflux of blood towards the capillaries They are very numerous in the veins of legs and neck They are absent for the most part in the veins in the great cavities of the body as the cranium, chest, abdomen

VASO VASORUM

They are the small vessels that nourish the coats of arteries and veins, they chiefly ramify in the outer coat

PHYSICAL PROPERTIES OF BLOOD-VESSELS

One of the most important properties is contractility of the vascular wall, in virtue of which the calibre of the vessel vary, and so the supply of blood to a part is altered Another property is dilatation of vessel wall after the contraction, which is brought about by its own elasticity and by the blood pressure

THE CAPILLARIES

They are not contractile, but they are elastic, and change in calibre are due to change in the blood pressures

ARTERIAL CIRCULATION

The arterial walls are both muscular and elastic, the muscular coat is greater in smaller arteries, whilst the elastic coat is stronger in the larger arteries The chief function of the elasticity of the larger arteries is to transmit unequal movement of the blood in the large arteries, caused by

the intermittent action of the ventricle, into a uniform flow in the capillaries Thus, when the ventricle contracts, the certain amount of blood is propelled into the aorta, which expands in all directions On the beginning of the diastole of the ventricle, the aorta by virtue of its elasticity recoils, so as to close semi-lunar valves on the one hand, and on the other hand to force the blood into the vessels further onwards Thus the blood is driven along the vessels by the action of the ventricular systole and elastic recoil of vessels wall, and along with it a series of movements consisting of expansions, and contractions travel from greater to smaller vessels These expansions and relaxations of arterial wall, passing along like wave, constitute the pulse

THE INNERVATION OF BLOOD-VESSELS

The changes in the calibre of arteries and veins are brought about by the influence of VASO-MOTOR nervous system This consists of VASO-MOTOR CENTRE and of vaso-motor nerves The vaso-motor nerves are of two kinds, viz —

(*a*) those the stimulation of which causes constriction of the vessels, called VASO-CONSTRICTOR nerves,

(*b*) those the stimulation of which causes dilatation of the vessels called VASO-INHIBITORY (vaso-dilator)

VASO-MOTOR CENTRE

It is placed chiefly in the pons varolli and the medulla oblongata, on the floor of fourth ventricle There are some vaso-motor cells

(1) In the spinal cord

(2) In some ganglia peripherally placed as vaso-motor centres, *e g*, as in connection with the sub-maxillary gland, lungs, abdomen, pelvis The centre is always in a state of activity, and this is probably automatic It is constantly discharging automatic impulses

THE COURSE OF THE VASO-CONSTRICTOR FIBRES

Some pass from the general centre in the pons and medulla into the fifth, vagi and ninth cranial nerves But most of the fibres pass down the lateral columns of the cord, and begin to leave it, chiefly through the anterior nerve roots of the spinal nerves from the second thoracic to the second lumbar, both inclusive From the anterior nerve roots they pass into the sympathetic ganglia (by means of the Rami communiconti), and then pass to the blood vessel either directly from the sympathetic plexuses, or else rejoin the cerebro-spinal nerves, and these pass with them to the blood-vessels

THE COURSE OF VASO-CONSTRICTOR NERVES ARE ASCERTAINED BY THE EXPERIMENT

BERNARD'S EXPERIMENT ON CERVICAL SYMPATHETIC NERVE OF THE RABBIT

First note the condition of the ear and side of the head and neck before division of the nerve. When the cervical sympathetic nerve is cut, the ear of that side becomes red and gorged with blood, the vessels being enlarged, and so also with the vessels at the side of the head, the temperature also of the parts is raised There is also an effect on the eye of that side It proves that impulses are always passing from the vaso-motor centre to the blood vessels and constricting them

STIMULATION OF DIVIDED NERVE

If the peripheral end be stimulated, the engorged vessels become constricted, the ear becomes paler than before and colder than the other one The vaso-constrictor nerve fibres are confined in the sympathetic system

The VASO-DILATOR or VASO-INHIBITORY nerves have been found in the ophthalmic division of the fifth nerve for the eye and nose, in the seventh nerve for sub-maxillary and sub-lingual glands, in the ninth nerve for the parotid, and they appear to be contained in the *anterior*

roots of spinal nerves generally They pursue a direct course in the mixed nerve trunk from the cord to the periphery, and retain the medullary sheath until they terminate In the limbs they are probably chiefly destined for the blood-vessels of muscles and sweat glands.

Section of vaso-dilator nerve, such as the chorda tympani of the seventh produces no effect on the vessels, but stimulation of its peripheral end causes great dilatation of all the arterioles, so that the sub-maxillary gland and neighbouring parts become red, and the pulse is propagated through to the veins, and there is free secretion of saliva

HOW THE POSITION OF VASO-MOTOR CENTRE IS ASCERTAINED ?

The position of the great vaso-motor centre is ascertained by three ways —(1) by measuring blood pressure, (2) by measuring calibre, (3) by measuring temperature

1 In the first place, a monometer is placed in an artery, say the femoral, to measure the arterial pressure A spinal nerve, say the sciatic, is next divided, and the central end is stimulated As a result of this, there is a rise in the blood pressure, owing to reflex stimulation of the vaso-motor centre in the pons and medulla The brain is then sliced away above the pons, but there is no fall in pressure, and the sciatic reflex effect is as great as before, because the vaso-motor centre does not extend into the brain above pons

Pons and medulla are now gradually sliced away from above downwards, and the blood pressure falls, and the sciatic reflex effect becomes less and less after every slice, because the vaso-motor centre is gradually removed

The centre is not entirely confined to pons and medulla LISTER'S EXPERIMENT showed that vaso-motor cells are found in the spinal cord

2 LISTER'S EXPERIMENT

Watch the effect of successive sections of a frog's spinal cord on the calibre of the vessels of the web As the

sections were made lower and lower down, the dilatation of the vessels of the web became greater and greater, because every section removed the foot from the influence of so many more vaso-motor cells in the grey matter of the cord

3 SCIFFS' EXPERIMENT

He noted the effect of successive sections of a dog's spinal cord on the temperature of a hind foot A thermometer was placed between the dog's toes, and as the sections were made lower and lower down, the temperature rose higher and higher

THE CONDITIONS THAT INFLUENCE THE ACTIVITY OF VASO-MOTOR CENTRE

1 THE STATE OF BLOOD —If the blood contains too little oxygen and too much carbonic acid, the centre is excited There is a general constriction of the blood-vessels and a consequent rise of the blood pressure, as in asphyxia

2 MENTAL STATE —Fear or intense anger causes constriction of the vessels, and the face becomes pale, shame and anger sometimes cause dilatation, and the face flushes as in "blushing"

CHAPTER IV.

BLOOD PRESSURE

It is the force with which the blood tends to escape from any blood-vessels.

IT DEPENDS ON—

1 The rapidity of the inflow, i e , the force of propulsion, and it varies with the heart

2 The rapidity of the outflow, i e , the force of resistance, viz , the friction of the fluid against the walls of the vessels, that is contraction of small arteries

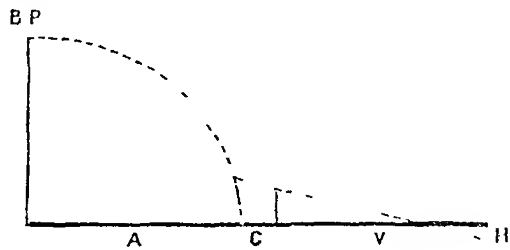
Note the immense importance of the muscular coat of the small arteries

In other words the blood pressure in any part of vascular system depends on the force of "propulsion" and the force of resistance

FOR PROPULSION —Heart is concerned in propelling the blood

FOR RESISTANCE —Arterioles and capillaries are concerned

The arterial blood pressure is the greatest by far in the arteries nearest the heart, less in the capillaries, and least in the veins At the beginning of the aorta the pressure is greatest and lessens as it proceeds, there is decided fall in the capillaries and a great fall in the veins The pressure is positive in the arteries, capillaries



Scheme of the Blood Pressure

B P = The height of the blood pressure
A = The arteries
C = Capillaries
V = Veins
H = Right auricles

and veins, except in the systemic veins near and in the chest, in which the pressure is negative during inspiration due to the elasticity of the lungs and heart

HALE'S METHOD OF MEASURING THE BLOOD PRESSURE

He inserted a vertical glass tube into the femoral artery of a horse and allowed the blood to flow in He noted the height to which the blood rose in the tube

POISEUILLE'S METHOD

He used an instrument called Poiseuille's Hæmodynamometer It consists of a U-shaped mercurial manometer, of which the short limb is connected by means of a leaden tube and canula with the interior of an artery The canula, leaden tube, and closed limb of the manometer are all filled with a saturated solution of sodium bicarbonate to retard coagulation of the blood The blood pressure is thus communicated to the upper part of the mercurial column, and the depth to which the column sinks in the one limb, added to the height to which it rises in the other, will give the height of the mercurial column which the blood pressure balances, the weight of the soda solution being deducted

The actual pressure in the caroted artery is 3 lbs 2 oz to the square inch

The blood pressure is subject to considerable variation The principal factors that cause variation are the following —

(1) Increase of pressure is produced by—

(*a*) Increase in the energy and rapidity of contraction of heart

(*b*) Increase in the quantity of blood, *e g*, after transfusion

(*c*) Increase in the contraction of arterioles—

This is brought about by giving cold bath, stimulating the general vaso-motor centre, drugs as digitalis

(2) Decrease in the pressure is produced by—

(a) Decrease in the rate and force of the heart-beat.

(b) Decrease in the quantity of blood

(c) Dilatation of arterioles—

This is brought about by warm bath, cutting the spinal cord, drug as nitrite of amyle

3 EXTRANEOUS MUSCULAR COMPRESSION — It raises the blood pressure everywhere, by directly squeezing the arterioles, and thus forcibly keeping the blood back in the aorta

4 RESPIRATORY MOVEMENT —

The blood pressure is lowered during inspiration and increased during expiration As during inspiration the expansion of the chest walls relieves the aorta from compression to a certain extent, and hence the fall of pressure. Further, the elasticity of the lungs causes a great recoil Reverse these conditions, and hence the rise in pressure

BLOOD PRESSURE IN CAPILLARIES

It depends on rapidity of inflow and outflow of blood The muscular fibres of arterioles are great regulators of capillaries pressure When arterioles are contracted, the pressure in capillaries falls, when they are dilated the pressure rises in capillaries, because more blood flows into them The lymph always is filtered through the walls of capillaries This is due to the pressure

THE EFFECT OF HEAT AND COLD

In hot climate the blood vessels of the skin are much dilated, and perspiration is going on and the blood pressure falls On the other hand sudden cold to the skin contracts the capillaries and increases the pressure in internal organs, and may be cause of inflammation of internal organs as the lungs, kidneys, &c , &c.

CHAPTER V.

THE PULSE

THE "PULSE" It is a wave produced by the temporary expansion and relaxation of vessel wall caused by the sudden injection of blood into it at each contraction of the heart The artery is elongated as well as laterally expanded, because it is elastic It recoils, allowing the blood to pass through the capillaries into the veins

AS ILLUSTRATED

1 THROUGH A RIGID TUBE —If fluid be driven through a rigid tube interruptedly, the flow from the tube is always interrupted, (just heart's action), however small the aperture of exit is made, as fluid are practically incompressible and the tube, not being elastic, it is impossible to heap up the fluid in it

2 THROUGH AN ELASTIC TUBE with large orifice If the inflow is interrupted, so is the outflow—as the elasticity of the tube is not called into play, since there is no resistance to the outflow the fluid gets out quickly

3 IF THE ORIFICE OF EXIT IN THE ELASTIC TUBE BE SMALL, then the outflow will be continuous, even though the inflow be interrupted In this case, there is resistance to the outflow, hence the tube being elastic, expands to accommodate itself to the supply, and the fluid is thus heaped up in it, and being under constant elastic pressure the outflow is constant, as it cannot get out so fast as it gets in

FURTHER—

EFFECT OF DILATATION OF THE ARTERIOLES

The pulse then passes through the capillaries into the veins, because the peripheral resistance is removed, but if

the arterioles are contracted, it is confined to the arteries

WHY IS THE PULSE CONFINED TO THE ARTERIES?

The pulse is usually extinguished at the capillaries and confined to the arteries, because of

(1) The resistance to the outflow offered by the contraction of the arterioles

(2) Elasticity of the arterial walls

(3) Further, the capacity of the capillaries is much greater than that of the arteries, and therefore they are not much dilated, and the flow through them is very much slower

EXAMINATION OF PULSE

"The examination of the arterial pulse is usually confined to the "Radial artery," and the part of the vessel subjected to investigation is that which lies immediately above the wrist, between the flexor tendons on the inner and the prominent ridge of the radius on the outer side In this situation the artery is very superficial and only covered by the skin and subcutaneous tissues, it can therefore be felt quite easily"

At this point, moreover, the shaft of the radius forms firm bony support, inasmuch as the bony floor upon which it lies gives a fixed base against which it may be firmly pressed When a finger is placed on the radial artery, one feels a distinct resistance at regular intervals corresponding to each beat of the heart The finger feels as if the artery is expanded

THE CHARACTER OF THE PULSE MAY BE EXAMINED BY—

I Instrument

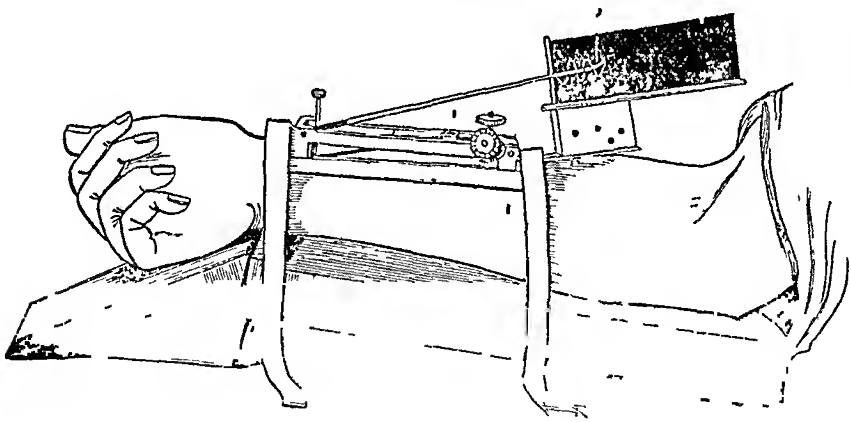
II The finger (palpation)

III The eye (inspection).

1. INSTRUMENT.—It is called SPHYGMOGRAPH. There are many varieties which are employed, and the only instrument can be recommended—MAREY'S, or MAHOMED'S or DUDGEON'S.

THE APPLICATION OF THE SPHYGMOGRAPH

In applying the instrument, make the patient to sit by the side of a low table, ask the patient to place the arm in a supine position resting upon the table. The fingers ought to be semi-flexed Mark the position of the pulse with ink The button of the instrument is placed on the marked position, and fixing it to the arm by the elastic strap Fix the smoke paper in the position The point yielding the largest movement of the lever has been ascertained

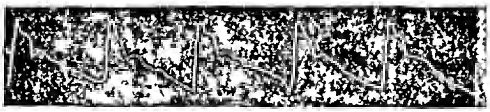


It is most important to regulate the pressure exerted upon the artery by means of the milled head This must be determined for each pulse, but the rule is to graduate the pressure until the greatest amplitude of movement of the lever is obtained Set the clock work going and a tracing is obtained

A SPHYGMOGRAPHIC TRACING OF THE PULSE.

It consists of a series of curves, each of which corresponds with one beat of the heart

A



B

In other words, one beat of the heart represents one curve of the pulse A single curve of the pulse indicates the following parts —

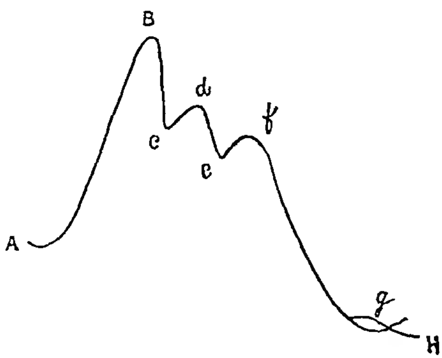
THE PARTS—I Primary wave
II Secondary wave

I PRIMARY WAVE

It consists of—

(1) The line of ascent or upstroke (a to b)
(2) The apex (b)
(3) The line of descent (b to h)

(1) THE LINE OF ASCENT or upstroke is almost vertical, and occurs during the dilatation of the artery produced by the systole of the left ventricle, when the aortic valve is opened and the blood is injected into the artrey



(2) THE APEX in a normal pulse is pointed

(3) THE LINE OF DESCENT is an oblique line on which we find the various secondary waves This line is

gradual and corresponds to the gradual contraction of the artery after cessation or the systole It has two distinct elevations or secondary waves

II THE SECONDARY WAVES

The secondary waves are found on descending part of primary wave They consist of

1 PRE-DICROTIC OR TIDAL occurs between the apex and the dicrotic wave (d) It occurs on the descent and during the contraction of the ventricles It is well marked in a hard pulse

THE CAUSE OF IT—It is said to be due to the inertia of the elastic wall, the vessel oscillating about its centre of equilibrium It is most marked when the arterial pressure is high, it is diminished or absent when the arterial pressure is low It is well seen in cirrhotic disease of the kidney, accompanied by hypertrophy of the left ventricle

2 DICROTIC WAVE OR RECOIL WAVE—It is also found on the descent (f) It is due to a rebound of the segmoid valves when the ventricle begins to relax, *i e.*, as soon as the segmoid valves are closed, and no more blood flows into the artery The arteries which were previously distended with blood suddenly thrown into them recoil or contract, so that in virtue of the elasticity of their walls they exert counter-pressure upon the column of blood, and thus the blood is forced onwards There is free passage of the blood towards the periphery, but towards the centre it impinges upon the already closed segmoid valves This developes a new wave It is most marked in a soft pulse It is not seen in rigid calcified arteries

THE HEIGHT OF ASCENT OF UPSTROKE

The height of the pulse depends on the power of the left ventricle and on the extensibility of the arterial wall The height of the wave in the aorta is lower than the femoral artery, because the walls of the aorta are thick and the wall of the femoral is more extensible, therefore the height is higher

THE OTHER WAVELETS

There are seen frequently other wavelets following the dicrotic wave, but these are due to elastic vibration of the arterial walls

SOFT PULSE

It indicates low arterial tension The dicrotic wave is well marked

HARD PULSE

This indicates high arterial tension The pre-dicrotic wave is most marked

THE SPECIAL USES OF THE SPHYGMOGRAPH

1 It gives accurate indications of the regularity of the pulse

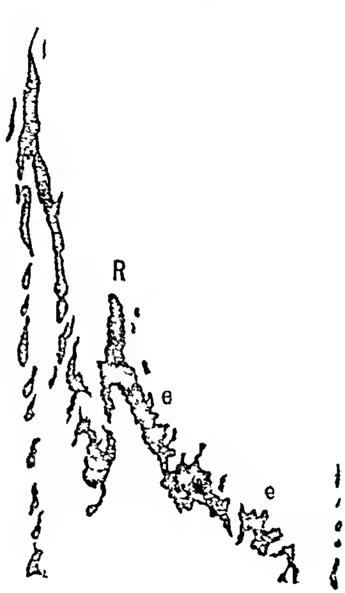
2 The state of the arterial tension—

Exaggerated dicrotic wave = low arterial tension
Exaggerated pre-dicrotic wave = high arterial tension

3 Strength of the left ventricle, as shown by the height of the upstroke

LANDOIS' METHOD OF STUDYING PULSE

He opened an artery and allowed the stream of blood to get against a revolving cylinder. Thus the normal curve of the pulse is obtained



II THE DIGITAL EXAMINATION OF THE PULSE (PALPATION).

It must be boine in mind that the sphygmograph is of limited use in diagnosing the disease

It brings into prominence certain points in regard to the pulse, which would be less definite without its aid, and it is on this account of some clinical interest

On the other hand there are some aspects of the pulse which can be much more accurately gauged by means of the finger than by the help of the sphygmograph

Lay the tips of the two fingers at first lightly upon the artery, and then pressure should be applied, and it should be varied in order to bring out the different phenomena in connection with the pulse It takes much practice for the physician to acquire the lactus eruditus Every physician must study the pulse beat very carefully There are three factors concerned in producing the pulse wave (1) the action of the heart, (2) the elasticity of the arterial walls, (3) the resistance in the small arteries and capillaries Alteration in any of these, or else pulse will be modified

PHENOMENA TO BE STUDIED

In the observation of the character of the pulse, attention should be devoted in turn to the following points —

1 The condition of the arterial walls

2 The state of the blood supply as regards

  (*a*) The fulness of the vessel

  (*b*) The tension of the artery

3 The character of the pulsation as regards

  (*a*) The rate of the arterial pulse

  (*b*) The rhythm of the arterial pulse

4 The character of each pulse-wave as regards

  (*a*) The size of the wave

  (*b*) The force of the wave

  (*c*) The duration of the wave

(SIR THOMAS GRAINGER STEWART)

1. THE CONDITION OF THE ARTERIAL WALLS

The walls of the radial artery are soft and yielding, and gives a feeling of elasticity to the fingers in health The breach of this healthy state is hardness and rigidity of the vessel When the walls are thickened, as in cirrhoses of the kidney, gives a feeling of hardness and of resistance when rolled side to side by the fingers

2 THE STATE OF THE BLOOD SUPPLY

This may be ascertained by estimating the fulness of the artery and the tension

(*a*) THE FULNESS OF THE VESSEL

This depends on the quantity of blood in the circulation, the energy of the heart's action and many others The fulness of the vessel may be judged by its size during the interval between two pulsations The full pulse has large pulse wave generally

(*b*) THE TENSION OF THE ARTERY

It is related with the activity of the heart and quantity of blood poured into the vessels during the systole This can be studied by applying the force of the fingers to the artery as much as to obliterate the artery during the interval between the pulsation This is termed by compressible and is synonymous with a pulse of a "low tension," while incompressible is a term equivalent to a pulse of a "high tension"

3 THE CHARACTER OF THE PULSATION must be observed with regard to its rate and rhythm

(*a*) THE RATE OF THE PULSE —In an adult man the number of pulsations usually varies between 60 and 72 per minute, in the female about 80 per minute In diseased condition it may be low or high An increase in the rate constitutes a "frequent pulse," and a diminution in the rate is termed an "infrequent pulse" The rate varies in health with sex, age, size, position, external temperature, hour of the day, condition of digestion, occupation Speaking generally, it may be said that the pulse is more frequent

in the following conditions —Female, childhood, infancy, small persons, upright attitude, high temperature, during the later periods of the day, after eating and drinking, and when engaged in any mental or muscular work, lastly the heat of the sun

(*b*) THE RHYTHM OF THE PULSE —On applying the fingers to the normal pulse, we feel beat after beat at equal intervals It is regular, in disease it may become irregular, or sometimes a beat is omitted called intermittent

4 THE CHARACTER OF EACH INDIVIDUAL PULSE WAVE

(*a*) The size varies according to the individual peculiarities of the person called—a large or bounding pulse, and a small or thready pulse

(*b*) THE FORCE —The force indicates energy of the cardiac systole

(*c*) THE DURATION —The quick or slow, it is easily tested by the fingers It indicates the relation existing between the dilatation of the artery by the blood current and its contraction during the passage of the blood into the capillaries

III THE EYE OR INSPECTION —It may reveal pulsation in the body as seen venous pulsation in very thin persons, or in case of neurasthenia and aneurism, the pulsatile movement of veins sometimes is seen in thin persons, and it is, as a rule, more visible in the external jugular vein It is produced by the contraction of the walls of the great veins and right auricle, which causes a current to flow backward as far as the valves on the veins The blood current is stopped there, but the closure of the valve communicates a distinct pulsation to the contents of the vein beyond, and every separate shock received by the valve is similarly transmitted to the blood above

THE VELOCITY OF THE PULSE WAVE

The pulse wave is transmitted throughout the arterial system from the root of the aorta. The velocity of the

pulse wave is 30 feet per second Weber estimated it at $28\frac{1}{2}$ feet per second It is shown by the experiment that the pulse appears at the wrist about one-tenth of a second, and in the dorsal artery of the foot about one-sixth of a second after the beat of the heart, and the distance from heart to foot is about 5 feet, and $5 \times 6 = 30$

THE TIME OCCUPIED FOR A COMPLETE CIRCULATION OF THE BLOOD —The time required by the blood to make a complete circuit through the course of the circulation is ascertained by injecting ferrocyanide of potassium into the cardiac end of the jugular vein, and the time noted at which its presence is detected in the blood of the peripheral end of the same vein It may be done also by injecting ferrocyanide of potassium into one jugular vein, and then drawing the blood at short intervals from the opposite jugular vein and testing for the presence of the salt In the rabbit it takes 7 7 seconds, and in the dog 16 6, to come to the opposite jugular vein In man it takes 23 seconds to complete the circuit

THE COURSE TAKEN BY A CORPUSCLE

It leaves the heart by the aorta and traverses the arteries that supply the alimentary canal, spleen, and pancreas It then passes through the capillaries of these parts, then the capillaries of the liver, then through the right side of the heart and the capillaries of the lungs, from which it returns to the left side of the heart, and again to the aorta, the point from which it started

THE RED CORPUSCLES CHIEFLY FLOW IN THE CENTRE OF THE VESSEL

As they are heavier than the white, and further they have smooth surfaces The white corpuscles are lighter than the red, and are pushed to the periphery, and roll along near the wall of the vessel, further they are viscous and stick here and there to the wall, and as the stream is rapid in the centre and slow at the periphery have something also to do with it

NATURAL ARREST OF HÆMORRHAGE

When an artery is divided in the living body, the blood spouts in jets from the heart into the end of the artery

1 The artery contracts because of the circular arrangement of the muscular fibres

2 It retracts within its sheath due to elasticity of its coats

3 The external covering "sheath" collapses

4 The blood coagulates and forms into "external clot," and this causes "temporary arrest"

5 Formation of the "internal clot," this

(1) protects the external clot and ultimately

(2) organises and leads to "permanent arrest" of the hæmorrhage

ARTERIAL HÆMORRHAGE

The blood is bright red, forced out in a jet, and pressure on the proximal side retards or stops the flow

VENOUS HÆMORRHAGE

There is a rapid flow of purple or black blood in a continuous stream from the distal end, but if the blood be exposed for a short time to the air, it rapidly becomes red The pressure on the distal side retards the stream

CAPILLARY HÆMORRHAGE

It is recognised by an oozing of bright blood from the whole surface of the parts and not from special points

LIGATURE OF AN ARTERY

It ruptures the inner coat, as it is very brittle The part beyond the ligature collapses and becomes smaller

CHAPTER VI.

BLOOD GLANDS

I. LYMPHATIC GLAND

STRUCTURE

There is a capsule of fibrous tissue, mixed with non-striped muscle, the capsule is incomplete at the hilus It ends in processes called Trabeculæ to form a supporting framework to the gland In the cortical part the processes are lamelliform, but in the medullary part they break up into cords or flattened bands In both cases, the alveoli thus formed freely communicate The cortical part is incomplete at the hilus In the alveoli we find the proper substance of the gland-follicular tissue Between the capsule and sides of the trabeculæ is a clear space, the lymph sinus, the sinus is traversed by retiform tissue, and its boundaries are lined with endothelial cells continuous with the cells lining the lymphatic vessels The fascicular tissue (in the central part of the alveoli) is made up of densely-packed lymph corpuscles, in processes of proliferation between the meshes of the supporting retiform tissue The blood-vessels do not pass into the lypmh sinus, the lymph corpuscles pass out of the follicular tissue into the lymph sinus by amæboid movement, perhaps assisted by contraction of the gland The efferent vessels open into the lymph sinus of the cortical part The efferent vessels take origin in the medullary part, and pass away at the hilus The lymphatic glands are found in the limbs, mesentery, pelvis, root of the neck The stream of lymph through the glands is very slow, the muscular fibres in the capsules contract and squeeze out the contents The changes that occur in the lymph in passing through the glands are—

The outgoing lymph contains

(1) Many young red blood corpuscles,

(2) Many white or lymph corpuscles, and therefore

(3) It shows a tendency now to coagulate

II THE SPLEEN

MEDICAL ANATOMY.

The spleen is situated between the ninth and the eleventh ribs on the left side It measures about five inches in length and three or four inches in breadth It lies in contact with the diaphragm as the latter arches upwards The organ presents a notch on its anterior border, the presence of which is of diagnostic value when the organ is enlarged and projects beyond the ribs The normal spleen cannot be felt When it is enlarged, however, it may project beyond the free edge of the ribs, and can then be felt in the left hypochondrium It moves during forced inspiration

STRUCTURE OF THE SPLEEN

1 SEROUS COAT —It is incomplete at the hilus

2 TUNICA PROPRIA (CAPSULE)—consists of elastic tissue and non-striped muscular tissue At the hilus it is reflected into the interior over the largest arteries, ensheathing them and ramifying with them, and joins the trabeaculæ sent in from the capsule

3 INTRA-VASCULAR NETWORK OR "SUPPORTING CELLS" OF THE PULP —This corresponds to the sinus of the lymphatic glands, only it is filled with blood instead of lymph

4 THE PULP —Like grumous blood, it bathes the supporting cells There are also yellowish pigment granules, and blood corpuscles are seen in every stage of regressive metamorphosis

BLOOD VESSELS OF THE SPLEEN

Both arteries and veins are very large compared with the size of the organ supplied They divide and subdivide at first, and the smaller branches of the arteries have the

trabeculæ and suddenly end in tufts or pencils of very small vessels. The outer coat and sheath of the smaller arteries become transformed in lymphoid tissue known as Malpighian corpuscles scattered here and there

FUNCTIONS OF THE SPLEEN.

1 It produces blood corpuscles

2 It destroys red blood corpuscles

The reason for believing that it produces red blood corpuscles are—

1 When the spleen is enlarged we get splenic leucocythæmia, there is a large number of white blood corpuscles in the blood

2 There are more white corpuscles in the blood of the splenic vein than in the splenic artery Coloured corpuscles are also produced, for the blood of the splenic vein contains young red blood corpuscles, these are not so biconcave, or red, so large as the ordinary red corpuscles, but when exposed to the air they become coloured The reasons for believing that it destroys red blood corpuscles are —

1 The blood of the splenic veins has fewer old red corpuscles than the blood generally Some of the pulp cells take the red corpuscles into their interior, break them down, and remove the hæmoglobin

2 The blood of the splenic vein has a red serum, due to the blood pigment liberated by the above-mentioned cells

3 The pulp is very rich in extractives and other waste products, probably from the breaking down of the red blood corpuscles

The spleen is not essential for life, if it be excised it is replaced, there is spleeniculi which enlarges to replace the organ It is enlarged in malaria and a good many other diseases It contracts rhythmically once a minute, and contraction lasts for about half a minute.

THE DRUGS AFFECT THE SIZE OF THE SPLEEN

Strychnine Quinine Ergot rye	all cause to contract the spleen
Eucalyptus Digestion	make it to dilate

III THYROID BODY.

It consists of two lateral lobes situated on each side of the trachea and larynx, and joined by an isthmus which crosses in front of the trachea at the level of the third and fourth rings It is larger in the female than in the male, it often increases in size about the menstrual period and pregnancy, it enlarges at puberty

THE STRUCTURE

It is surrounded by a very vascular capsule, and consists of a number of closed vesicles, each vesicle is surrounded by a plexus of capillaries, and lined by a single layer of cubical epithelium resting on a basement membrane, each vesicle contains a clear, yellowish, albumenous, viscid fluid, and sometimes white corpuscles and degenerated red corpuscles

ITS FUNCTION

It is not known, though it is included amongst the blood glands

Its supposed function is that it removes that poison from the blood which, if retained, causes poisoning of nervous system If thyroid is removed from man, a serious effect is produced If removed from dogs and apes, death soon occurs Professor Horsley distinguishes three stages after removal of the thyroid gland in monkeys, (1) neuratic, (2) mucinoid, (3) atrophic

Probably its normal functions are to keep the blood pure and free from some pernicious products, the nature of which has not yet been discovered In the clinical observation it is found to be concerned with two chief

diseases If its activity is increased, causes disease called Exapthalmic Goitre On the other hand if its activity is diminished causes disease called Myxœdema, which thyroid feeding cures the disease

IV THYMUS GLAND

It is also a blood-forming gland found in the root of the neck, anterior mediastinum, in early life It has a capsule sending inward septa or trabeculæ, gland substance is made up of lymph follicular tissue It has cortex, medulla, and the medullary part contains Hassal's corpuscles

V SUPRA-RENAL BODY

It consists of—

(1) A cortical part

(2) A medullary part, separated from the cortical part by a layer of loose connective tissue

(i) CORTICAL PART

It consists of a fibrous stroma, in the meshes of which are cells arranged in columns, which radiates from the centre of the gland

From without inwards we find—

(1) Zona glomerulosa

(2) Zona fasciculata

(3) Zona reticularis

(ii) MEDULLARY PART

It consists of a delicate reticular stroma, in the meshes of which we find granular cells, some of them branched

The function of the organ is not known, the organ is concerned in "Addison's disease"

VI RED BONE MARROW

It is a very important tissue in which blood corpuscles are formed It occupies in the cancellous tissue of bone It is very vascular, nourishes the spongy part of the bone

It has small amount of fibrous tissue as a matrix in which is included medullary cells, from these cells red corpuscles are formed by the transformation of the cells. The yellow marrow becomes fat If red marrow is administered to anæmic persons rapidly, Hb are produced

THE LIST OF BLOOD GLANDS

Lymphatic gland	Red marrow
Spleen	Solitary glands
Thyroid	Peyer's glands
Thymus	Lymp follicular tissue

CHAPTER VII.

PHYSIOLOGY OF RESPIRATION.

The object of respiration is twofold One is the supply of oxygen to the tissues, the second is an excretory process by which carbonic acid (CO_2) and watery vapour formed within the body are removed The most important organs for this purpose are the lungs The respiration is divided into AN INNER and AN OUTER respiration

The INNER RESPIRATION consists in the interchange of oxygen and carbonic acid between the tissues and the blood

THE OUTER RESPIRATION consists of the interchange of carbonic acid and oxygen between the blood and the air

The RESPIRATORY PASSAGES ARE—the lower part of the nose, the upper part of the pharynx, the larynx, trachea and bronchi

STRUCTURE OF THE TRACHEA

The trachea is about 4½ inches in length, it extends from the sixth cervical to the fourth or fifth dorsal vertebræ

1 The external sheath for the trachea surrounding and joining together the cartilages is a fibro-elastic membrane

2 CARTILAGES —They form incomplete rings, they are C-shaped, forming about three-fourths of a circle, being incomplete behind They are embedded in the fibro-elastic membrane These cartilages are from 16 to 20 in number and consists of hyaline cartilage

3 A MUSCULAR LAYER —A layer of non-striped muscle is present behind, connecting this incomplete portion

of the cartilages together, and is also present behind in the intervals between the rings This layer of muscle is also covered on both surfaces by the fibro-elastic membrane before mentioned This is called Trachealis muscle supplied by the recurrent laryngeal nerve

4 SUB-MUCOUS COAT, consisting of loose connective tissues, containing many mucous glands, blood-vessels, adipose tissue, and longitudinal bundles of yellow elastic tissue

5 MUCOUS MEMBRANE —This consists of—

(*a*) A layer of stratified ciliated epithelium, the upper layer being ciliated There are also a few "goblet cells" The cilia lash upwards

(*b*) A basement membrane of flattened epithelial cells

(*c*) A layer of adenoid tissue and capillaries

(*d*) A longitudinal layer of fine elastic fibres in bundles

Fig 14 Mucous membrane of Trachea

THE BRONCHI —They are divided into EXTRA-PULMONARY BRONCHI and INTRA-PULMONARY BRONCHI

THE EXTRA-PULMONARY BRONCHI in structure resemble the trachea, as they pass into the lung they divide very frequently, and branches do not anastomose

THE INTRA-PULMONARY BRONCHI divide and subdivide, and become finer and finer as subdivision takes place, the finest branches being called terminal bronchi or bronchioles, which open separately into clusters of air-vesicles

In the structure the larger intra-pulmonary bronchi differ from that of the trachea in the following respects —

1 The connective tissue does not form a compact fibro-elastic membrane, but is in the form of a loose layer of cellular tissue, through which the large blood-vessels run

2 The cartilages now form irregular plates, and are not confined to one particular place

3 The muscular tissue forms a complete ring inside the cartilaginous plates

4 THE SUBMUCOUS COAT —Consisting of areolar tissue mixed with much adenoid tissue sometimes arranged in the form of cords, the lymph-follicular cords

5 MUCOUS COAT —Its usual characters are retained, only it is thinner, consisting of the following layers from within outwards—

(1) Stratified columnar ciliated epithelium.
(2) A basement membrane
(3) Transparent homogeneous basement membrane
(4) Areolar tissue with longitudinal elastic fibres
(5) A continuous layer of non-striped muscular fibres disposed circularly (bronchial muscle)

THE LUNGS

Coverings of the lungs—

(1) A serous covering, the pleura pulmonalis
(2) Sub-serous areolar tissue, with many elastic fibres this layer is continuous with that within the lung

Each lung is divided into apex, base and root The right lung has three lobes and the left two Each lobe is made up of lobules of various sizes, usually about the size of

peas, each lobule is pear-shaped, with the broad end to the outside The lobules are best seen on the cut surface of a fœtal lung Between the lobules we find fine connective tissue with many elastic fibres Each lobule may be regarded as a miniature lung, each one having a terminal bronchiole, and branch of the pulmonary artery and vein.

TERMINAL BRONCHIOLE

After repeated subdivisions, the bronchial tube, when reduced to 1 mm, is called a Terminal Bronchiole

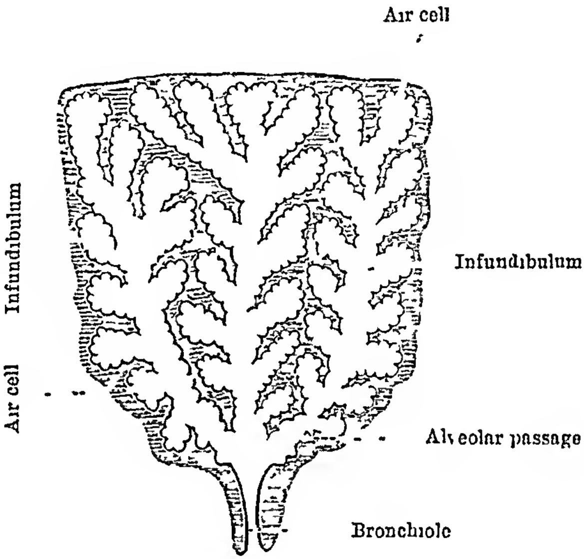


Fig 15 Scheme of a bronchiole terminating in alveolar passages, those leading into infundibula beset with air-vesicles

The terminal bronchiole branches into several wider tubes called alveolar ducts or infundibula, and each of these again branch into several smaller ducts All the infundibula are closely beset in their whole extent with polygonal vesicles The "air cells" or alveoli opening by a wide aperture into the infundibular passages, but not communicating with each other All the infundibula with their air-cells, belonging to one terminal bronchiole, forms a lobule of the lungs Infundibula are lined with cubical non-ciliated cells, with here and there some squamous epithelial plates.

STRUCTURE OF THE MINUTE BRONCHI OR BRONCHIOLES

There is an alteration in the structure of the bronchi, as we proceed from the larger to the smaller tubes The cartilages, mucous glands, and ciliated epithelium are absent They simply consist of—

(1) A fibrous sheath

(2) A well-marked layer of elastic tissue which continue on to the air-cells, and help to form their wall

(3) An equally well-marked layer of non-striped muscular fibres The muscular fibres are continued into the alveolar passages and infundibula, but do not surround the air-cells

(4) A single layer of cubical epithelium on a basement membrane

ALVEOLI OR AIR-CELLS

The form of the air-cells which are 25 μ ($\frac{1}{100}$ inch) in diameter, may be more or less spherical or cup-shaped They are disposed around and in communication with the alveolar passages

STRUCTURE FORMING THE WALL OF AN ALVEOLUS

(1) It consists of a delicate fibro-elastic tissue with coiled elastic fibres continuous with the outer coat of the terminal bronchiole

(2) This is lined by a single layer of squamous epithelial cells The muscular coat of the bronchiole is not continued on to the air-vessels

(3) Surrounding each vesicle there is a dense network of capillary blood-vessels from the pulmonary artery and vein There are also in the alveolar wall rootlets of lymphatic vessels

BLOOD VESSELS OF THE LUNG

1 The pulmonary artery and vein (lesser circulation)

2 The bronchial artery and vein

THE PULMONARY VESSELS run in the connective tissue that separates the lobes and lobules towards the infundibula and air-cells The branches of the pulmonary artery do not anastomose each other, and ultimately they terminate in small arterioles, each arteriole splitting up into capillaries for several air-cells On the other hand the pulmonary vein usually anastomose An efferent vein usually arises at the opposite side of the air-cells and carries away the purified blood from the capillaries In their course these veins unite to form the pulmonary veins

The pulmonary arteries convey venous blood (dark blood) to the lungs to be arterialized, and the pulmonary veins carry away red, pure blood (arterial blood) The veins are not more capacious than the arteries, and they have no valves

2 THE BRONCHIAL VESSELS pass along with the bronchi, and chiefly serve for the nourishment of the lungs. The bronchial arteries arise from the aorta, and usually three to each lung

The blood which issues from their capillaries is returned partly by the pulmonary veins, hence any considerable interference with the pulmonary circulation causes congestion of the bronchial mucous membrane resulting into a catarrh

THE LYMPHATICS OF THE LUNGS

They are arranged in two sets—

(1) A SUB-PLEURAL set, communicating with the pleural cavity through the stomata

(2) A DEEP SET

(*a*) In the walls of the air-cells often peri-vascular

(*b*) In the walls of the bronchi often peri-bronchial

NERVES OF THE LUNGS

The nerves are derived from the vagi and sympathetic, which form the anterior and posterior pulmonary plexuses, and from these branches enter at the root of the lungs, and

follow the course of the air-tubes and probably end in the alveoli

FUNCTIONS OF THESE NERVES

The sympathetic is vasomotor, the vagus is motor to the bronchial muscles, and sensory to the mucous membrane of the bronchi and air-vesicles

PHYSICAL PROPERTIES OF THE LUNGS

The lungs, in virtue of the large amount of elastic tissue which they contain, are highly elastic, and when the chest is opened they collapse The healthy lung is light, spongy, floats in water

If a healthy lung be squeezed between the fingers, it emits a peculiar fine crackling sound, owing to the air within the air-cells A similar sound is heard on cutting the vesicular tissue of the lung

The lungs of the fœtus, before respiration has taken place, sink in water, but after respiration the lungs float which shows that respiration has been established in the lungs after birth This hydrostatic test is largely used in medico-legal cases as a test of the child's having breathed The great function of the lungs is the aeration of the blood The mucous discharged in the bronchi gives moisture to the air and entangles solid particles The cilia of the epithelium moves the mucous into the trachea and to the pharynx

MECHANISM OF RESPIRATION

The mechanism of respiration consists in an alternate dilatation and contraction of the chest The dilatation means "expansion," it is an act of inspiration The contraction means "partial collapse," it is an act of expiration

FOR THE INSPIRATION the chest cavity is enlarged by the action of certain muscles, the pressure within the lungs becomes less than that outside, and therefore the air rushes in to equalise the pressure on the inside and outside of the chest When the muscles relax the lungs tend to

collapse due to elasticity, and expel the contained air, by the action of the elastic tissue of the lungs and various other agencies

FOR THE EXPIRATION the cavity of the chest is thus lessened, the pressure within becomes greater than that of the atmosphere without, and therefore the air is forced out

CHANGES IN THE CHEST DURING ORDINARY INSPIRATION.

The chest is enlarged in three diameters by the descent of the diaphragm and elevation of the ribs—

1 IN AN ANTERO-POSTERIOR DIAMETER —The ribs are attached obliquely to the spine and sternum The elevation of the ribs takes place, hence, the distance between them and the spine is increased just as when one raises the handle of a bucket The intercostal spaces are also widened

2 IN THE TRANSVERSE DIAMETER, as the ribs rise they rotate round an axis uniting their vertebral and sternal ends, their external surfaces, which looked downwards and outwards, now look directly outwards In ordinary respiration the upper end of the sternum and the first rib do not move, in forced respiration the sternum does move In laboured respiration all parts of the chest move, the sternum is thrown forwards and upwards, and the ribs raised

3 IN THE VERTICAL DIAMETER —This is affected by the contraction of the diaphragm At rest the diaphragm is dome-shaped, presenting a convex surface to the thorax, in contracting, this surface becomes flatter, the floor of the chest is lowered, the cavity of the thorax enlarged, and the air enters to distend the lungs

The contraction of the diaphragm tends to press the abdominal viscera downwards, and causes the walls of the abdomen to project during inspiration.

MUSCLES OF ORDINARY INSPIRATION

1 DIAPHRAGM, the most important It descends, becomes flatter by contraction of its fibres, and thus the vertical diameters are increased The first two ribs are firmly fixed by the scaleni, then the sternum is thrown upwards and forwards, the ribs raised and rotated by—

2 EXTERNAL INTERCOSTALS their fibres pass downwards and forwards

3 LEVATORES COSTARUM—They elevate the sternal end very much

4 INTERNAL INTERCOSTALS—The action of these muscles is somewhat doubtful, but they probably raise the ribs, so the ordinary inspiration is purely a muscular action

ORDINARY EXPIRATION

It is purely a physical action, *i e*, non-muscular It is brought about by means of—

1 THE ELASTICITY OF THE LUNGS—During inspiration the elastic tissue of the lungs is put upon the stretch, but when the muscles of inspiration relax, there is an elastic recoil, and part of the air is forced out This elasticity cannot cause the lungs to collapse because it cannot create vacuum in the pleural cavity

2 The weight of the chest wall, *i e*, gravity

3 The elasticity of the costal cartilages, by being elevated they are slightly twisted during inspiration, but when the muscles relax, they tend to untwist themselves

4 The elasticity of the abdominal wall when the diaphragm descends, it presses down the abdominal viscera, and puts the abdominal wall on the stretch When the muscles of inspiration relax, it tends to recoil, and press the abdominal viscera up against the diaphragm again

MUSCLES OF FORCED INSPIRATION.

Every muscle that can, either directly or indirectly, raise the ribs is brought into play

1 Those that raise the hyoid bone (indirect elevators of the ribs)—

(*a*) Genio-hyoid
(*b*) Mylo-hyoid
(*c*) Stylo-hyoid
(*d*) Digastric

2 Those that raise the sternum directly—

(*a*) Sterno-hyoid
(*b*) Sterno-thyroid
(*c*) Thyro-hyoid
(*d*) Sterno-cleido-mastoid

3 Those that raise the upper ribs—

(*a*) Scaleni
(*b*) Cervicalis ascendens
(*c*) Serratus posticus superior

4 Those that pull the scapulæ upwards and backwards and fix them—

(*a*) Trapezius
(*b*) Levator anguli scapulæ
(*c*) Rhomboideus major
(*d*) Do minor

5 Those that pull up the ribs by taking a fixed point from the elevated shoulder bones

(*a*) Serratus magnus
(*b*) Pectoralis major
(*c*) Do minor
(*d*) Sub-clavius

MUSCLES OF FORCED EXPIRATION

1 Those that press up the contents of the abdomen against the diaphragm—

(*a*) Obliquus externus.
(*b*) Do internus
(*c*) Transversus abdominis
(*d*) Levator ani

2 Those that depress the ribs—

(a) Rectus abdominis
(b) Longussimus dorsi
(c) Quadratus lumborum
(d) Serrates posticus inferior
(e) Triangularis sterni

THE "TYPES OF RESPIRATION"

In young children respiration is chiefly carried on by the diaphragm, and as this descends, it presses upon the contents of the abdomen, and pushes out the anterior abdominal wall very markedly This movement of the abdominal wall being more manifest than that of any other part, this form is spoken of as the *abdominal type* of respiration

In men, in addition to the above, the lower part especially of the chest is subject to a wide movement in inspiration, this is spoken of as the *inferior costal type* of respiration

In women, on the other hand, the movement is less extensive in the lower part of the chest and abdominal wall, and marked in the upper part of the chest, and this is spoken of as the *superior costal type* of respiration Hence, speaking in a general way, the abdominal type is more marked in the male and the costal type in the female

RELATIVE DIMENSION OF THE CHEST

The diameter of the chest is measured by means of callipers

"In strong men the circumference of the upper part of the chest (immediately under the arms) is 88 centimeters (34 3 inches), in females 82 centimeters (32 inches), at the level of the ensiform process 82 centimeters (32 inches) and 78 centimeters (30 4 inches) respectively In health the chest expands from 1½ to 5 inches during forced inspiration

"When the arms are placed horizontally, during moderate expiration, the circumference immediately under the nipple

and the angles of the scapulæ is equal to half the length of the body, in man 82, and during deep inspiration 89 centimeters The circumference at the level of the ensiform cartilage is 6 centimeters less"

This measurement is very important for the Government service.

(WILLIAM STIRLING)

NUMBER OF RESPIRATION

In the adult usually 16 to 24 per minute, in the child about 40 per minute The pulse-beats are 4 beats during each respiration The number of respirations is influenced by many conditions —

1 In diseased states it may range from 7 to 100 per minute

2 It is naturally slower in sleep

3 The position of the body horizontal position 13, sitting 19, standing 22 respirations per minute

4 The temperature of the surrounding medium The respiration become more rapid, this occurs when the actual temperature of the blood is increased as in fever

RESPIRATORY MOVEMENT

The respiratory movement may be registered by the instrument called the Stethograph of Marey Each respiratory act consists of two parts *inspiration* and *expiration*

Inspiration is slightly shorter than expiration, and it begins suddenly and advances rapidly to completion Expiration begins immediately after, and at first advances rapidly, and then very slowly Some physiologists give name to this slow part *pause* It is not really pause.

The relative lengths of the movements of inspiration and expiration may be expressed thus —

Inspiration expiration 5 6

RESPIRATORY SOUNDS

In health practically two breath sounds—

1 Vesicular

2 Bronchial

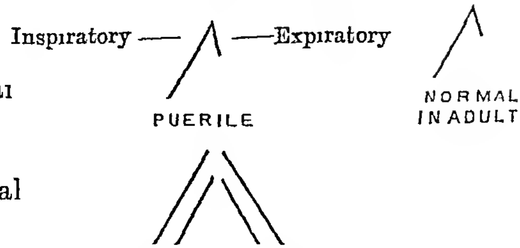


Fig 16 These lines are representing sounds

These sounds are due to the friction of air in the respiratory passages, chiefly at two points—the glottis (producing the bronchial murmur), and at the point where the bronchioles join the alveoli (the vesicular murmur)

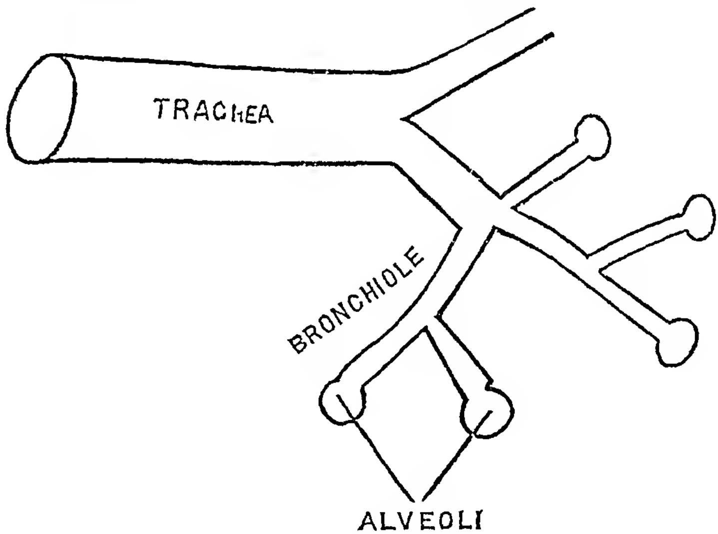


Fig 17 Scheme showing the relation in production of sounds

1 VESICULAR BREATH-SOUND

It is due to the entrance and escape of air into and out of the air vesicles It is just like air passing through a tube into a small closed room, the entrance and escape of air into and out of the room produce sound The sound is represented in the diagram above

CHARACTER OF THE SOUND —It is compared to the rustling of the leaves It is a soft, breezy

It consists of two murmurs, the one corresponding to inspiration, the other to expiration

Inspiratory sound represented in the diagram by a single line is a fine, continuous, rushing sound, soft in the adult and loud in the child (puerile), and audible from beginning to end of the act

THE EXPIRATORY SOUND—on the other hand it may be absent during quiet breathing in healthy persons It is thin in quality, soft, sighing in character caused by the air passing out of the air vesicles It is three or four times shorter than the inspiratory, *i e*, the inspiratory part is longer, softer, louder, because air passing from small space (bronchioles) into a larger one (air-vesicles) make a greater sound Its absence is not a sign of disease, it can be brought out by causing the patient to breathe deeply

N B—When the expiratory part of the vesicular sound is prolonged, it often means IMPENDING PHTHISIS This sound is best heard over the apex and base of the lungs

2 BRONCHIAL BREATHING OR TUBULAR

Bronchial sound is produced chiefly in the larynx, owing to the formation of air-eddies in consequence of the narrowing of the respiratory part of the glottis, and the sound is carried downward having friction against the bronchial wall

CHARACTER OF THE SOUND—It is harsh, blowing sound It is imitated by holding the tongue in the position for the pronunciation of ch sound (as in the German word *Ach* or the Scotch word *Loch*) The sound is represented in the above diagram by a double line. The inspiratory and expiratory sounds are of equal length, and there is a distinct pause between the inspiratory and expiratory sound

This sound is best heard over the trachea, and between the scapulæ and over the upper part of the sternum If

the sound is heard over the other part of the lungs in higher pitch, it indicates consolidation of lung substance, such as that of pneumonia In the healthy chest the respiratory sounds are purely vesicular (without harshness or prolongation of expiration) over the whole surface of the lungs, except the part where the bronchial breathing is heard, over the apex of the right lung, where in health the vesicular breath-sound is generally a more or less prolonged, and often harsh

NERVE MECHANISM OF RESPIRATION

In the central nervous system there is a localised district called the *respiratory centre* The centre gives out impulses which travel down the spinal cord to the nerves of muscles of respiration It also receives afferent fibres from the vagus

THE RESPIRATORY CENTRE

The centre is placed in the medulla Respiration goes on in the absence of consciousness, after the removal of the brain above the medulla, but destroy the medulla and it stops The centre is bilateral—a bilateral inspiratory, and a bilateral expiratory—these centres are co-ordinated and act as one The centre extends from near the root of the vagus to the calamus scriptorius If the medulla be split up into the middle line and destroy the half, there is bilateral paralysis of respiration

THE MOTOR NERVES OF ORDINARY INSPIRATION

1 Phrenic nerves to the diaphragm

2 Intercostal nerves to the intercostal muscles and levatores costarum

3 Inferior laryngeal nerves to the crico-arytenoid muscles that open the glottis

THE RESULT AFTER DIVIDING THE SPINAL CORD JUST BELOW AND ABOVE THE ORIGIN OF THE PHRENICS

Divide the spinal cord just below the origin of the phrenic nerves, it results in paralysis of all the muscles of

expiration (forced), and some of the muscles of inspiration The diaphragm being not paralysed, the respiration will go on

Section of the spinal cord above the origin of the phrenics results in death, because all the respiratory muscles are paralysed The centre, however, is still active, because the respiratory movements of the glottis and nose still go on, but when the facial and recurrent laryngeal nerves are cut, these stop also

THE RESULT AFTER DIVIDING THE PHRENICS

Divide both, the diaphragm is completely paralysed Still death does not result at once, because the muscles that raise the upper ribs are sufficient for a time to carry on respiration, but it becomes excessively laboured

IS RESPIRATION VOLUNTARY OR INVOLUNTARY?

The respiratory movements are usually involuntary It goes on in the absence of consciousness and after all the brain is removed above the medulla oblongata

THE EXCITING CAUSE OF RESPIRATION

The exciting cause is referable to the state of the blood, especially to deficiency of oxygen The deficiency of oxygen affects the respiratory centre chiefly directly, but it may also do it indirectly through the pulmonary branches of the vagi which contain afferent fibres to convey impulse from the lungs to the inspiratory centre The vagi are stimulated, either by the condition of the blood in the capillaries, or the altered air in the air vesicles acting on the nerve endings, and impulses are then sent up to the centre in the medulla Divide one vagus, and the respiration is slowed, the impulses passing up must therefore excite the inspiratory centre Cut both vagi, there is great anxiety of breathing

The inspiratory centre is always being stimulated through the vagi, divide and stimulate the upper end—

(1) Gently—Respiration is accelerated

(2) Powerfully—Respiration is stopped, with the diaphragm brought to rest in a state of spasm as if it were a constant inspiratory effort, as indeed it is The vagi therefore contain fibres which are excito-motor for the diaphragm

Thus pulmonary branches of the vagus contain two sets of fibres—

(1) The inspiratory, that go to the centre for inspiration these are always in action, exciting that centre

(2) The expiratory, that go to the centre for expiration this set is brought into use when there is, for example, an accumulation of mucous in the bronchi, and the result is a cough, to expel it

HOW THE CENTRE IS AFFECTED DIRECTLY

Cut off the blood supply from the medulla (by ligaturing the vertebral and internal carotid arteries) there is an increase of carbonic acid, and a decrease of the available oxygen in that region, and the result is dyspnœa This shows that the oxygen affects the centre directly

EFFECT OF HEAT ON CENTRE

When the temperature of the blood is above normal, the centre is excited and hypernœa and dyspnœa are produced, *e g*, overheat the blood in the carotid artery In fevers also the same thing is seen, the rapid respiration being due to the high temperature, the heated blood acting directly in the centre

EFFECT OF WILL ON RESPIRATION

The will can either excite or inhibit inspiration or expiration, even though the impulse has begun in the centre, it can even affect forced expiration, *e g*, coughing

SUPERIOR LARYNGEAL BRANCH OF THE VAGUS

This is the sensory nerve of the larynx It contains fibres that can affect both respiratory centre

Cut both nerves, there is no change in the respiratory movement, and therefore they are not usually in a state of activity, as far as respiration is concerned

Stimulate the upper end of the divided nerve, we note four effects —

(1) Pain, as the nerve is a sensory one
(2) The animal swallows.
(3) There is an inhibition of inspiration
(4) There is an excitation of expiration, and the diaphragm is brought to rest in a state of relaxation

The example for this is—

When a crumb of bread goes below the glottis—goes the "wrong way"—we note—

(1) Inspiration is inhibited, so that the crumb is not drawn down

(2) Expiration is excited, a cough results, and so it is driven out.

ACTION OF CUTANEOUS NERVES ON RESPIRATION

When cutaneous nerves are stimulated, the inspiratory centre is stimulated, *e g*,, a dash of cold water on the face, or a cold bath in the winter During fainting, the dash of cold water on the face stimulates the respiration Or to stimulate the infantile breathing dipping the baby into hot and then cold water stimulates the respiration

MODIFIED RESPIRATORY MOVEMENTS

(I) —COUGHING

It is a sudden violent expiratory movement. There is previously a deep inspiration, followed by closure of the glottis, then a sudden forcible expiration, which bursts open the glottis, and any substance in connection with respiratory mucous membrane is driven out through the mouth It is a reflex act

THE MECHANISM OF COUGHING

1 The SENSORY SURFACE—from which the impulse is conveyed through afferent nerve to the centre, thence energy is discharged through efferent nerves.

2 The afferent nerve is nearly the vagus

3 The centre involved is the expiratory centre

4 The efferent nerves are those that supply the muscles of extraordinary expiration

5 The muscles are those of extraordinary expiration

The cause of coughing is irritation of the sensory surfaces

SENSORY SURFACES.

1 The mucous membrane of the stomach, *e g.*, coughing in dyspepsia where the gastric branch of the vagi are stimulated

2 Irritation of the pharynx, *e g*, coughing due to elongated uvula

3. Irritation at the back part of the tongue In this case the efferent nerve is a twig of the superior laryngeal nerve distributed to the dorsum of the tongue.

4 Cold acting on the skin of the upper part of the body This may lead congestion of blood in the air-passages, exciting cough

5. In some diseases of the liver, spleen, and generative organs, when pressure is exerted on these parts

(II) —SNEEZING

It is a sudden expiratory blast driven through the nose, the soft palate and anterior pillars of the fauces shutting off the mouth from the pharynx It is a reflex act

NERVE MECHANISM CONCERNED

1 The sensory surfaces are usually either the mucous membrane of the nose or the retina.

2 The efferent nerves the sensory nerves of the nose—nasal branch of the 5th, the other part of mechanism is the same

THE EXAMPLES OF IRRITATION CAUSING SNEEZING

A pellet of mucous in the nose, or from tickling the nose, or other forms of irritation as snuff, &c A bright light acting on the retina It is said that sneezing may be stopped by pressure on the side of the bridge of the nose and coughing cannot be stopped

(III) —HICCOUGH

It is due to a spasmodic contraction of the diaphragm, causing an inspiration, which is arrested by the sudden closure of the glottis, and air just entering strikes against the closed glottis and so that a sound is produced It is sometimes very troublesome symptom in uræmic poisoning

THE NERVES CONCERNED ARE—

The afferent nerves are the gastric branches of the vagus the glottis is closed by the inferior laryngeal, the phrenics to the diaphragm are of course involved as well It is said that it may be arrested by—

(1) A deep inspiration kept in as long as possible to steady the diaphragm.

(2) Swallowing piece of ice, and allowing them to melt in the stomach

(3) Apply traction to the tongue

(IV) —SNORING

It occurs during respiration through the open mouth. The expiratory and inspiratory stream of air throws the uvula and soft palate in vibration

RELATION OF AIR TO RESPIRATION

TIDAL AIR —It is the air which is constantly passing in and out of the chest during ordinary breathing It is 20 cubic inches

COMPLEMENTAL AIR —It is the air that can be drawn into the chest, over and above the tidal air, by a forced inspiration It is 120 cubic inches.

RESERVE AIR —It is the air that can be expelled by a forcible expiration, over and above the tidal air It is 90 cubic inches

RESIDUAL AIR —It is the air that still remains in the lungs even after the most forcible expiration It is 90 cubic inches

VITAL OR RESPIRATORY CAPACITY

It is the amount of air that can be driven out of the chest by the most forcible expiration, after the deepest inspiration It is 230 cubic inches It includes—

The tidal air	= 20	cubic inches
The complemental air	=120	„
The reserve air .	= 90	„
Total	230	

COMPOSITION OF ATMOSPHERIC AIR

	N	O	CO_2
Inspired air contains	79 15	20 81	0 04
Expired air contains .	79 587	16 03	4 38
Difference	0 437	4 78	4 34

CHANGES IN THE AIR BY RESPIRATION

1 Air loses oxygen by 4 77 per cent, 26 oz in twenty-four hours, in other words, amount of oxygen absorbed in 24 hours = 26 ounces

2 Air gains carbonic acid 4 34 per cent, 8 oz in 24 hours, in other words, amount of carbon excreted in 24 hours = 8 ounces

3 It gains heat if the temperature of the air be 20 C, then the expired air in the mouth will be about 33 9 C

4 It gains moisture 9 ounces in twenty-four hours

5 It gains various organic impurities—putrescible organic matters

The putrescible organic matter in the air may be detected—drive air through water, the water very soon gets bad smell, and begins to putrify or pass the air through a solution of permanganate of potassium, it is soon reduced and becomes less red

The amount of oxygen inhaled per hour is 1,584 cubic inches or about 542 grains The amount of carbonic acid exhaled per hour is 1,346 cubic inches or about 636 grains

CONDITIONS AFFECTING THE EXCRETION OF CARBONIC ACID

1 MUSCULAR EXERCISE —More O is absorbed, and carbonic acid excreted during muscular work.

2 Food More O is absorbed and CO_2 excreted when food is taken

3 *Nature of Food* —Most carbonic acid excreted on a flesh diet

4 *Daily Variation* —Less during the night At night more oxygen absorbed than carbonic acid excreted, least at midnight, most at midday

5 *Temperature* —When the temperature of air is high, excretion of CO_2 diminishes On passing suddenly from a cold to a warm medium CO_2 is diminished, and conversely on passing from a warm to a cold excretion CO_2 is increased

6 *Age* increases till thirty years, is then stationary to forty, and after this diminishes till seventy years of age

7 *Sex* —More by male than female In female the increase stops at puberty, and remains stationary during menstrual life

8 *Light* —More CO_2 excreted in bright light, dark, gloomy rooms are unhealthy

THE GASEOUS INTERCHANGES IN RESPIRATION

I.—THE INTERCHANGE BETWEEN THE BLOOD AND THE TISSUES

(1) The tissues are always removing oxygen from the lymph, and therefore the tension of oxygen in the lymph

is lowered, and hence oxygen is disassociated from the oxyhæmoglobin of the blood and carried out into the tissues because oxyhæmoglobin is not a very stable compound, and requires a certain tension of oxygen to keep it in combination. The oxygen in arterial blood has a high tension, the tension of oxygen in the tissues is kept low, because the tissues are constantly using it up, and hence the oxygen passes into the tissues and they stow it away.

(2) The carbonic acid produced in the tissues from metabolic changes passes into the blood-capillaries As the tension of CO_2 within them is less than in the tissues, because it is being constantly produced in the tissues The salt of blood, sodium carbonate, becomes sodium bi-carbonate in the capillaries.

II.—THE INTERCHANGE IN RESPIRATION BETWEEN THE BLOOD AND THE AIR.

(1) In the air vesicles of the lungs the tension of oxygen is higher than in the blood returned from the tissues, and therefore it diffuses through the alveolar membrane to the capillaries, the oxygen immediately combines with the hæmaglobin

(2) On the other hand, the tension of carbonic acid is greater in the venous blood returned to the lungs than in the air vesicles, and therefore it passes from the blood into the air vesicles The sodium bi-carbonate in the lungs break up into H_2O and CO_2 which we get into expired air.

THE EFFECT OF BREATHING AIR VITIATED BY RESPIRATION

After having been once breathed, the air of the room loses oxygen, and gradually gains CO_2 and watery vapour and putrescible organic matter. The organic matter increases as the CO_2 is increased, and therefore the quantity of this latter substance present in a room may be taken to indicate the organic impurity of the air vitiated by respiration above The characteristic and disagreeable odour of

crowded rooms, hospital wards, and bed rooms, when improperly ventilated, is due to this organic matter, which is dangerous to human life This gives rise to symptoms—headache, muscular pains, drowsiness, and general impairment of health

Breathing space should be allowed 750 to 100 cubic feet, and to keep this pure the air must be changed three or four times every hour Every individual requires 3,000 cubic feet of fresh air per hour.

MODIFIED BREATHING

APNŒA —If expiration and inspiration are brought about together hurriedly, and alternately at a rate quicker than natural breathing, the respiration ceases for a short time

HYPERNŒA—*Exaggeration of breathing* —When an animal is not supplied with a due amount of air from any cause, normal expiration becomes deep and anxious This soon becomes worse, and respiration becomes deep and hurried, giving us a condition of dyspnœa

DYSPNŒA—difficulty of breathing, and this leads to ASPHYXIA or suffocation

CHEYNE-STOKES' RESPIRATION

"It is an altered respiratory rhythm This consists of a period of perfect apnœa succeeded by feeble and short inspiration, which gradually increase in strength and depth until the respiratory act is carried to the highest pitch, when the inspiration pursuing a descending scale regularly diminish until the commencement of another apnœal period This peculiar breathing occurs in certain disease, where the normal supply of blood to the brain is altered, and also when the quality of blood itself is altered. It is well seen in *uræmic poisoning*"

ASPHYXIA OR SUFFOCATION

The symptoms are divided into three stages —

1*st Stage* —Hypernœa, soon followed by dyspnœa,

when both movements of expiration and inspiration are exaggerated The face becomes blue, and there is rise of pressure It is due to powerful stimulation of the respiratory centre by increasing venous blood

2nd Stage —This is a short stage, the animal becomes anxious and convulsive

3rd Stage—Unconsciousness, convulsions, and paralysis of the respiratory centre due to venous blood circulating in the brain There is fall of pressure Then paralysis of heart, and death During this stage the pulse is imperceptible, but the heart may beat for some seconds

CAUSES —Anything that prevents the O of the air reaching the blood, or the blood reaching the oxygen, such as—

(1) Breathing vitiated air

(2) Obstruction to the entrance of oxygen to the lungs and blood

(3) Blood not passing to the lungs

(4) Alteration of the hæmoglobin

(5) Loss of blood

CIRCULATORY CHANGES IN ASPHYXIA

At first the systemic blood pressure rises greatly, but the pressure in the pulmonary artery only to a slight extent. This rise is due to the venous condition of the blood stimulating the vaso-motor centre in the medulla The heart is now enfeebled by the venous blood circulating in the coronary vessels, and the left side may come to a standstill for a time owing to the great resistance to its contraction The vaso-motor centre becomes paralysed from want of oxygen, the systemic vessels then dilate, and the blood pressure falls almost to zero, while the left ventricle resumes beating feebly The blood now accumulates on the right side of the heart and in the systemic veins, as the weakened right ventricle is unable to drive it through the lungs

POST MORTEM OF HEART

The right side of the heart, the systemic veins and the pulmonary arteries are gorged with dark blood, the left half of the heart, the pulmonary veins, and the arteries are almost empty

TREATMENT OF ASPHYXIA

TRY TO RESTORE THE CIRCULATION AND RESPIRATION

For Circulation—Hot cloth, or a hot sponge over the region of the heart, rubbing the limbs, sometimes venesection from the external jugular to relieve the engorged right heart

For Respiration—Apply artificial respiration There are various methods

ORIGIN OF MUCUS, SPUTUM

Respiratory mucous membrane is normally covered with a thin layer of mucus, and new mucus secreted which is removed The increased secretion of mucus indicates congestion of mucous membrane

SPUTUM.—In normal state it is mucus mixed with saliva, which is coughed out from the back part of the throat

EXAMINATION OF THE CHEST

(i) Inspection and mensuration

(ii) Palpation

(iii) Percussion

(iv) Auscultation

These four foregoing principles should be kept in the mind for the examination of the chest

BY INSPECTION we ascertain the following —

(1) FORM AND SIZE OF CHEST—

(*a*) Circumference of chest at line of nipple.

(*b*) General form (flat, barrel-shaped, &c)

(c) Local alteration in form (local flattening, bulging, unilateral alteration)

(2) MOVEMENT OF CHEST—

(a) Number of respiration per minute

(b) General type of movement (thoracic, abdominal, thoracic-abdominal)

(c) Rhythm and volume of respiration, and their special character as in Cheyne-stoke

(d) Sucking in of intercostal spaces

BY PALPATION we make out vocal fremitus It is vocal vibration, the sound of the voice transmitted through the chest, and perceptible to the touch We note increase or decrease

BY PERCUSSION, *i e*, tapping the chest wall by means of the fingers, we determine the condition of the lungs at different area. The normal percussion sound is clear or resonant and abnormal following —

(1) *Hyper-Resonance*

(2) *Deficient Resonance*, *i e*, dulness

(3) Mixture of dulness, *i e*, boxy note

BY AUSCULTATION we ascertain the following —

(1) Expiration, (2) character, (3) accompaniments, (4) vocal resonance

(i) *Expiration*—prolonged or normal

(ii) Character of breathing —

(a) *Vesicular*—Puerile, normal, feeble, non-interrupted, harsh

(b) *Bronchial.*—The normal situation for this breathing is described previously, if detected on any other, situation is abnormal Tubular, cavernous

(c) *Amphoric* or whistling

(iii) *Accompaniments*—These are accessory sounds produced in morbid condition of the lungs, which are designated as accompaniments.

(*a*) *Dry Sounds or Rhonchi*.—This indicates swollen mucous membrane of the tubes or thick fluid lying in the bronchial tubes or spasmodic contraction of the bronchi This also may be as wheezing or sibilant, sonorous

(*b*) *Moist Râles or Crepitations*.—This denotes the presence of air and thin watery fluid produced in the alveoli and pulmonary cavities The sounds resemble those produced when salt is thrown into the fire or rubbing the hair between the fingers. This also varies fine, medium, coarse

(*c*) *Friction*.—It is heard in pleuræ, the sound resembles those produced by rubbing two pieces of leather.

(4) *Vocal Resonance*.—It is vibration produced by consonanting sounds within the lungs This varies—

(*a*) Increased, slight, marked, very marked.

(*b*) Decrease, slight, marked, total.

(*c*) Qualitative alteration.

Ægophony (nasal timbra) metallic echo.

CHAPTER VIII.

PHYSIOLOGY OF GASTRO-INTESTINAL DIGESTION

The digestive organs are the alimentary canal The alimentary canal is a tube about 28 feet long It commences at the orifice of the mouth, and terminates at the orifice of the anus It is divided into series of parts These parts are named mouth, pharynx, œsophagus, stomach, small intestine, and the large intestine As the food-stuffs are carried along the alimentary canal, they undergo changes by the action of different juices These juices are saliva, gastric juice, pancreatic juice, bile, intestinal juices, which being

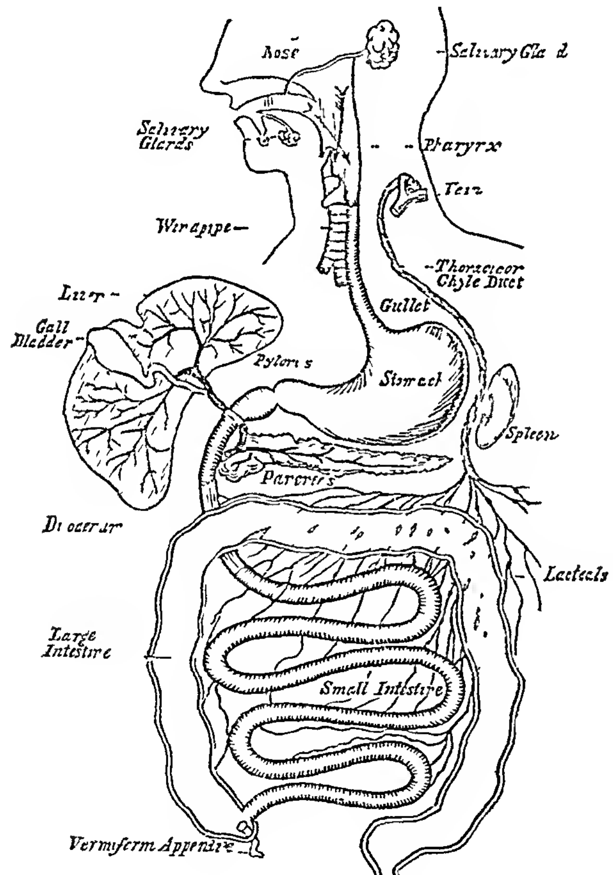


Fig 18
(After Stirling)

secreted by different glands are poured out into the canal

to act on *food-stuffs, making* them soluble and diffusible The digested products are absorbed for the nourishment of the body The undigested part of the food pass as fæces by the anus

DIGESTION—Consists in rendering food-stuffs soluble and diffusible so that they can pass into the blood

ASSIMILATION—Means conversion of food into nutriment

NUTRITION—Is the means by which new material is conveyed to the tissues of the body, and also by which it is got rid of when it has served its purpose, and become effete or useless

THE OBJECTS OF NUTRITION ARE—

(1) To build up new tissues and repair the old

(2) To yield the various forms of energy, *e g* , to produce heat—to do bodily work—to do mental work, &c

THE FOOD-STUFFS ARE CLASSIFIED AS—

(1) Proteids, (2) Fats, (3) Carbo-hydrates, (4) Minerals and water

GASTRIC DIGESTION

(INCLUDING MOUTH, PHARYNX, STOMACH).

THE MOUTH AND ITS GLANDS

The mouth is situated in the face, and extends from the lips in front to the pharynx behind The mucous membrane which lines the mouth is beset with numerous glands secreting mucus, but the chief glands from which the cavity of mouth receives its secretion are the *salivary glands*

THE SALIVARY GLANDS

There are three pairs of salivary glands, parotid, sub-maxillary, and sub-lingual They differ from each other in structure and secretion

(1) The parotid is a *true salivary* gland

(2) The human sub-lingual is a *true mucus* gland

(3) The human sub-maxillary is a *muco-salivary* gland

All these glands are compound tubular glands Each gland has a framework of ordinary fibrous tissue arranged in a loose capsule sending inward septa that divide the gland into lobes and again sub-divide into lobules and finally into acini

STRUCTURE OF THE PAROTID GLAND

The parotid lies close to the auricle, and its duct is "Stenson's duct" It passes over the massoter muscle, perforates the buccinator muscle, and opens into the mouth opposite the second upper molar tooth The duct is traced back The main duct divides into lobes and then into lobular, and then again into intralobular ducts which again giving rise intermediate duct terminate into secreting acini or alveoli

STRUCTURE OF DUCTS

All the ducts are lined by columnar epithelium, except the intermediate duct which is lined by cubical epithelium They have basement membrane, and a layer of non-striped muscular fibres arranged circularly in larger ducts only

STRUCTURE OF ALVEOLI

They are formed by a basement membrane, and lined by a layer of short columnar cells with round nuclei The cells are very granular and almost fill the alveoli

THE CHANGES DURING REST AND DURING SECRETION

During Rest—the cells become larger and granular, they (the cells) almost fill the alveoli, no lumen being visible

During Secretion—the granules are washed away

After Secretion—the granules disappear, the cells have become smaller, and the lumen larger

STRUCTURE OF THE SUB-LINGUAL GLAND

The sub-lingual gland lies beneath the tongue, and has a number of small ducts, the ducts of Rivini, some of which open separately, but one large one unites with Wharton's duct

As compared with the parotid the tubes are larger, contain a larger lumen, and have larger cells lining them The cells are of two kinds,—(1) mucous or central cells, which are transparent columnar cells with nuclei near the basement membrane These cells yield mucin, (2) semi-lunes of Heidenhain or crescents of Gianuzzi, are cresentic masses of granular parietal or marginal cells found here and there between the basement membrane and the central cells. They are small and very granular at rest.

THE CHANGES IN THE CELLS AT REST AND AFTER SECRETION

The central cells in their *resting state* contain a transparent substance called Mucigen—the cells being large, transparent, spheroidal, and nearly fill the alveoli

During Secretion—When the gland is secreting, the mucigen is converted into mucin, and discharged into the lumen of the alveolus, the cells swell up, appear more transparent

During Rest—the cells become smaller and more granular

The Parietal cells (semi-lunes) increase in size during secretion.

STRUCTURE OF THE SUB-MAXILLARY GLAND

It lies under the horizontal ramus of the lower jaw, and its duct is Wharton's duct, opens in the floor of the mouth at the side of the frœnum of the tongue It is a mixed or muco-salivary gland, and parts present the structure of true salivary, and other parts of true mucous glands, thus it has structure of two glands mixed

NERVES OF SECRETION FOR THE SUB-MAXILLARY AND SUB-LINGUAL GLANDS

These glands are supplied by Chorda Tympani, from facial nerve and sympathetic fibres, from the superior cervical ganglion

CHORDA TYMPANI —It is a branch of the facial NERVE (seventh cranial), and joins the lingual branch of the fifth under the lower jaw, goes to anterior two-thirds of the tongue and part of its fibres leaves the lingual, goes to sub-maxillary ganglion, and from there to the glands It contains the following fibres —

(1) It has secretory fibres to the secreting cells of the gland.

(2) Vaso-inhibitory fibres passing to the sub-maxillary ganglion

EXPERIMENT

Put a canula into the duct of the sub-maxillary or the sub-lingual gland, and then stimulate the chorda tympani You notice—

(1) There is a rapid flow of very watery, limpid saliva-*Chorda-saliva*

(2) There is a great dilatation of the blood-vessels of the gland

(3) There is further a production of heat during secretion

The rapid flow of saliva is not due to the dilatation of the vessels As a matter of fact, each is brought about by the independent action of special nerve-fibres, so that two functionally different kinds of nerve-fibres occur in the chorda tympani

EXPERIMENT IN ITS PROOF

Give the animal a dose of atropine, the secretory set of fibres of the chorda are paralysed, but not the vaso-inhibitory On stimulation now the vessels dilate as before, but there is no secretion of saliva. Hence the flow of

saliva is not the result of the dilated state of the vessels, and is not therefore a mere act of filtration, but is a *vital* process

FURTHER PROOF

It was shown by Ludwig that the pressure of the salivary secretion in Wharton's duct may considerably exceed the blood pressure in the arteries, this being so, the rapid flow of saliva could not be due to mere filtration, nor directly, dependent upon the dilated state of the vessels. The water is not secreted by filtration, but by vital action of the cells

Monometer is placed, one in Wharton's duct and the other in the carotid artery, chorda is divided and stimulated It is found that the pressure of salivary secretion is much higher than that of the artery

SYMPATHETIC NERVE gives branches to all the salivary glands The secretory fibres come from the centre through the spinal cord The fibres leave the cord at the lower part of the neck and enter the superior cervical ganglion thence to the glands

ACTION OF THE NERVE —It is the nerve for secreting solids

EXPERIMENT IN ITS PROOF

Divide the sympathetic in the neck, and stimulate the upper end We note—

(1) There is a scanty secretion of very viscous and thick saliva, rich in salivary corpuscles, the specific gravity is high, and the action on the starch is powerful It is called sympathetic saliva

(2) The blood-vessels of the gland are very markedly constricted

The sympathetic contains two sets of fibres—(1) secretory fibres for solids, (2) vaso-constrictor fibres.

NERVES OF PAROTID GLAND.

1 Fibres that pass from the glasso-pharyngeal, through its tympanic branch, through the tympanic plexus to the small superficial petrosal nerve and otic ganglion, and thence by the auriculo-temporal nerve to the parotid gland

2 Sympathetic, from the superficial cervical ganglion

POSITION OF THE SALIVARY CENTRE

It is probably at the upper part of the medulla, but higher centres exist on the surface of the brain, where the sensation of taste is perceived by the mind

When the brain is sliced above the medulla, there is still secretion, and when the medulla is sliced the secretion stops

EXCITING CAUSES OF SALIVARY SECRETION

1 It is usually a reflex act

PROOF —Place a cannula in Wharton's duct in a dog during fasting, no saliva will flow out, now apply tasteful substance, *e g* , salt or acid to the mucous membrane of the mouth or the tongue, there is copious flow of saliva Further , divide the chorda tympani, the secretion stops, hence, the secretion is due to reflex act

AFFERENT NERVES IMPLICATED

1 Lingual branch of the fifth to the anterior two-thirds of the tongue Chorda tympani is the efferent nerve carrying impulses from the centre to the glands

2 The glasso-pharyngeal nerve to the posterior-third of tongue

3 Long buccal to the cheeks

4 The gastric branches of the vagus —This acts as afferent nerve, when emetic is given, the excitement is sent from the stomach to the centre A rush of saliva into the mouth usually precedes the act of vomiting

II EMOTIONAL STATES —The mouth may "water" at the sight or thought of food Fear may have an opposite effect, and stop the secretion entirely

III. MOVEMENT OF THE JAWS.—These movements seem to increase the flow of saliva

IV VARIOUS DRUGS

(a) *Atropine* stops the secretion

(b) *Pilocarpine* causes a great flow of saliva

(c) *Acetic acid* causes a great increase in the flow of saliva

In ordinary circumstances the secretion is always watery (chorda saliva) But when the nerves concerned are stimulated, there is reflex secretion of proper saliva

PARALYTIC SECRETION OF SALIVA

When the nerves of a gland are all divided, the gland begins to secrete thin watery saliva, and goes on till the cells are exhausted

GENERAL CHARACTERS OF THE SALIVA OBTAINED FROM INDIVIDUAL GLANDS

1 PAROTID SALIVA —This is the most watery It is clear limpid, and not viscid, and not very alkaline On standing it becomes turbid from the precipitation of calcium carbonate It contains globulin, but no mucin, and no corpuscles It has a powerful action on starch than the secretion of the other glands It contains *ptyline* The parotid is a *true salivary or serous gland*

2 SUB-LINGUAL SALIVA —The saliva is most viscid of the three, and contains more solids than either of the other two, though it does not seem to be so powerful in its action on starch The sub-lingual is *true mucous gland*

3 SUB-MAXILLARY SALIVA —The saliva is more alkaline and viscid than that of the parotid saliva It contains many corpuscles, and much proteid matters It is the most active of the three in transforming starch into sugar

GENERAL CHARACTERS OF THE MIXED SALIVA

1 PHYSICAL CHARACTERS —It is colourless, tasteless, odourless, viscid, frothy, alkaline fluid of sp gr 1004

to 1008, containing about ½ per cent of solids It contains detached squamous cells, and salivary corpuscles The amount secreted in twenty-four hours 7 to 50 oz

(2) CHEMICAL COMPOSITION

1 Water		995 16 per 1000
2 Organic solids—	Epithelium Salivary corpuscles	1 62 „ „
	Ptyline Mucin Albumen Globulin	1 38 „ „
3 Inorganic solids		1 84

Are—Sodium, potassium chlorides,
Potassium phosphate,
Alkaline and earthy phosphate,
Ferric phosphate, sulphocyanide

PTYLINE is a hydro-lytic ferment, because it causes the substance acted upon to take up water It has special action on starch It is not used up or destroyed in the conversion of starch into maltose In other words it undergoes no change, called therefore "Catalytic" It is sometimes termed *amylolyatic* ferment

FUNCTIONS OF SALIVA—Mechanical and chemical.

I MECHANICAL

(*a*) It moistens the mouth and assists speaking

(*b*) It assists mastication and deglutation (by moistening food, lessens friction in swallowing)

(*c*) It assists gustation, because it dissolves substances, and the solution then affects the taste-buds

II. CHEMICAL

It transforms starch into *dextrin* and *maltose*, after various intermediate stages, during digestion

THE CONDITIONS REQUIRED FOR ITS ACTION

1 Moderate heat—about the temperature of the body, 100° F A temperature above 140° F kills it

2 It is most active in a slightly alkaline or neutral medium, it may also act in a slightly acid medium, though the presence of $\frac{1}{10}$ per cent of hydrochloric acid is sufficient to stop its action

3 It acts much more quickly on cooked than upon raw starch It has no action on fats and proteids

ITS ACTION IS RETARDED BY

(1) *Cold* —If frozen, its action is stopped at least for a time

(2) The presence of acids and strong alkalies

ACTION OF SALIVA ON STARCH

Starch consists of granules, enclosed in an envelope of *cellulose* Saliva has no action on cellulose, so that saliva acts very slowly on raw umboiled starch When starch is cooked, so as to swell up the starch-grains, the cellulose coat of the granules is ruptured, and therefore the saliva performs its own action on starch rapidly The symbol for starch is $C_6H_{10}O_5$ The action of saliva on starch depends on the presence of a ferment called—

PTYALIN —This ferment converts the starch into "Maltose" or grape-sugar, after various intermediate stages The stages are the following —

Saliva + Starch	
Erythro-dextrin	Achroo-dextrin
Maltose or grape-sugar	

These stages may be recognised by the following process

If saliva be added to starch paste and the whole kept at the temperature of the body, the following changes occur —

(1) IODINE—at first will give a *blue colour*, showing the presence of unchanged *starch*

(2) IODINE—added later, gives a *reddish brown* colour, from the presence of *Erythro-dextrin*

(3) Later on again iodine gives no colour at all   This is because of the presence of achroo-dextrin

(4) In the last step of the process, when *Fehling's solution* is added, we get a red precipitate—the sugar is now present   It is supposed at first to take up one molecule of water thus —

3 $(C_6H_{10}O_5)$ + H_2O = $C_6H_{12}O_6$ + 2 $(C_6H_{10}O_5)$ this last being dextrin

Then dextrin takes up more water thus —

$$\begin{array}{lcl} 2\ (C_6H_{10}O_5) + 2\ H_2O & = & 2\ C_6H_{12}O_6 \\ \text{2 Dextrin} & = & \text{2 maltose.} \end{array}$$

MASTICATION

THE MOVEMENTS OF THE JAWS AND MUSCLES CONCERNED

1 THE JAWS ARE CLOSED BY—

(1) Masseter
(2) Anterior part of temporal
(3) Internal pterygoid

2 THE JAWS ARE OPENED BY—

(1) Gravity

(2) Muscles that draw down the hyoid bone—sterno-hyoid, omo-hyoid, and platysma

(3) Mylo-hyoid, genio-hyoid, and chiefly by the digastric

3 THE GRINDING MOVEMENT

By the alternate action of the two external pterygoids, combined with the action of the elevators of others

4 PROTRACTION BY—

The two external pterygoids acting together, assisted by the masseter and internal pterygoid

5 RETRACTION BY—

The posterior fibres of the temporal.

6 The buccinator and orbicularis oris keep the food from passing into the internal between the teeth and the cheek The tongue also moves the food from side to side, and squeezes the softer parts of it against the hard palate

THE TONGUE.

THE INTRINSIC AND EXTRINSIC MUSCLES OF THE TONGUE.

I The INTRINSIC (confined to the tongue)—

(1) SUPERFICIAL LINGUAL—Longitudinal fibres just beneath the mucous membrane These fibres turn up the lip of the tongue

(2) INFERIOR LINGUAL—A round muscular band along the under surface from base to apex This muscle turns down the tip of the tongue

(3) TRANSVERSE FIBRES—These form the greatest part of the substance of the tongue They narrow and elongate the tongue

(4) VERTICAL FIBRES—These form a series of curves from the dorsum to the under surface

II The EXTRINSIC (take their origin elsewhere, but attached to the tongue)

(1) STYLO-GLOSSUS—In deglutition these muscles raise the sides of the tongue, and form a hollow on the dorsum of the tongue

(2) The hyo-glossus opposes the stylo-glossus, and makes the dorsum convex

(3) Genio-hyo-glossus—

Posterior fibres protrude the tongue,

Anterior fibres retract it,

The middle part, or muscle as a whole, depresses it.

THE TEETH

THERE ARE TWO SETS OF TEETH

1 The tempoiary oi milk-teeth—twenty in number (Two molars, one canine and two incisois in each half of each jaw)

2 The peimanent set—thiity-two in numbei (three molars, two bicuspids, one canine, and two incisois in each half of each jaw) Each tooth consists of a poition above the gum called *ciown*, and a part embedded in the gum called the fang, and a pait between the two called the neck, so theie are three paits visible to the naked eye, *ciown*, *neck*, and *fang*

MICROSCOPIC STRUCTURE OF TOOTH

It consists of four parts on section

(1) The pulp, filling a central space, the pulp cavity

(2) The dentine, surrounding the pulp cavity

(3) The enamel, covering the dentine in the crown

(4) The cement, covering the dentine in the fang

1. STRUCTURE OF THE PULP

The pulp fills the pulp cavity, and consists of a delicate connective tissue, containing numerous cells, vessels and neives The cells lie close to the dentine, foiming a regular layer, and are called *odontoblasts*, *i e*, those cells which build up the dentine

2 STRUCTURE OF THE DENTINE OR IVORY

It consists of tubules embedded in a calcified matrix, chemically like that of bone, but stiucturally different, as the oiganic pait is not fibious but homogenous The tubules by their inner ends communicate with the pulp cavity, and by theii outei ends come into contact with the undei part of the enamel and cement In their course foim parallel curve and branch dichotomously

DENTINAL TUBULES —Each tubule contains a fine fibie, the "dentinal fibre" These fibres are processes of

cells, or *odontoblasts* which are columnar cells lining the pulp cavity

3 STRUCTURE OF ENAMEL

The enamel covers the crown of the tooth It is very hard and consists almost entirely of earthly salts It is composed of six-sided prisms set endwise on the dentine They are disposed in wavy and parallel curves The prisms are solid and are marked by transverse lines

4 STRUCTURE OF THE CEMENT.

The cement or crusta petrosa is simply a thin plate of bone It consists of bone corpuscle in lacunæ, with canaliculi embedded in a matrix of calcified fibrous tissue arranged in lamellæ It is harder than ordinary bone

DEVELOPMENT OF THE TOOTH

It is developed from the mucous membrane of the maxillary ridges, the enamel being formed from its epithelium, and the remaining dental tissues from the subepithelial connective tissue, the whole part concerned being known as the dental germ The following are the chief steps of the process —

1 About the end of the second month of fœtal life the epithelium proliferates and forms two ridges—the *dental ridges*—with a shallow groove between, called the superficial dental groove

2 The deeper part of the epithelium grows down obliquely into the soft connective tissue, forming the deep dental groove This extends all round the gum, and is filled with epithelium called the common, or enamel germ

3 Flask-like dilatation occur in deep dental groove, due to proliferation of the epithelial cells These mark the site of the future teeth, and the epithelium filling each flask is known as the *enamel organ*

4 A papilla grows up at the base of each flask and indents it, and is called the dentine germ, as it forms the

dentine and tooth pulp The papilla consists of mucous connective tissue and blood-vessels The enamel is formed from the enamel organ that covers the dentine germ

The papilla becomes continuous and covers the enamel organ called dentinal sac The cement is formed by the ossification of the inner and lower connective tissue of the dentinal sac

DENTITION

MILK TEETH —The first dentition begins at the sixth or seventh month, and is completed by about the second year

Central incisors	(1) lower, 6th month,
	(2) upper, 7th month
Lateral incisors	(1) upper, 9th month,
	(2) lower, 10th month
1st molars	12th month
Canines	18th month
2nd molars	2nd year

The full primary dentition is twenty teeth ten in each jaw

PERMANENT TEETH

1st molar	6½	years
Lower central incisors	7	"
Upper central incisors	8	"
Lateral incisors	9	"
1st bicuspid	10	"
2nd do	11	"
Canines	12	"
2nd molars	13	"
3rd molars (wisdom)	17	to 25 years

THE PHARYNX

There are six distinct openings into the front part of the pharynx A pair of the hinder openings of the nasal cavities, and at the sides close to these, a pair of the apertures of the Eustachian tubes The two single

apertures are the hinder opening of the mouth between the soft palate and the epiglottis, and behind the epiglottis, the upper aperture of the respiratory passage Between the anterior and posterior arches of the soft palate are situated the tonsils, one each side

THE MUCOUS MEMBRANE—The upper part is lined with ciliated columnar epithelium The lower part and the œsophagus are lined with stratified squamous epithelium The pharynx is well supplied with mucous glands

DEGLUTITION

The food is transmitted to the stomach by the act of deglutition or swallowing

It is divided into (1) A VOLUNTARY STAGE

(2) AN INVOLUNTARY STAGE

(1) VOLUNTARY STAGE

The food is made into round bolus by the tongue The bolus is pushed towards the pharynx, being pressed between the tongue and the palate The tongue is shortened and the tip is raised against the hard palate By approximation of the tongue to the palate, the bolus is driven backwards

(2) INVOLUNTARY STAGE

This stage begins when the bolus reaches the posterior third of the tongue

1 THE FOOD IS PREVENTED from passing into the larynx The vocal cords of the larynx draw near to one another, the epiglottis is pushed backwards over the larynx, and the whole larynx is drawn suddenly upwards and forwards beneath the root of the tongue In this manner the entrance into the respiratory passages is protected

2 THE FOOD IS PREVENTED FROM PASSING INTO THE NOSE—The soft palate is raised and made

tense, and is met by the wall of the pharynx Thus the opening into the posterior nares is blocked up

3 Lastly, by the contraction of the constrictor muscles the pharynx is drawn up to meet the descending bolus

THE ŒSOPHAGUS

It extends from the cricoid cartilage, opposite the sixth cervical vertebra, and passes through the diaphragm on a level with the ninth dorsal vertebra It has externally a fibrous covering, *viz*, the following coats —

1 MUSCULAR COAT IN TWO LAYERS —

(1) External longitudinal layer

(2) Internal circular layer

2 SUBMUCOUS COAT —Consists of areolar tissue combined with racemose glands

3 MUCOUS COAT —It is lined by stratified squamous epithelium.

GASTRIC DIGESTION

STRUCTURE OF THE STOMACH

The walls of the stomach are composed of four coats —

1 SEROUS COAT —It is derived from the peritoneum It covers all over except at the two curvatures of the stomach

2 MUSCULAR COAT —It consists of three sets of non-striped muscular fibres —

(1) LONGITUDINAL LAYER —It is directly continuous with the longitudinal fibres of the œsophagus, and remains continuous with the longitudinal fibres of the duodenum

(2) CIRCULAR LAYER —It is thickened at the pylorus, forming its sphincter

(3) OBLIQUE LAYER OR INNER —It is incomplete and chiefly marked at the cardiac and pyloric ends

3 SUBMUCOUS COAT —This coat lies between the muscular and mucous coat, and consists of areolar tissue and blood vessels

4 MUCOUS COAT.—It is loosely attached, so that when the stomach is empty, it is thrown into rugæ. It is pale pink in colour, but during digestion it is bright red, accompanied by secretion of gastric juice. After death it is a dirty brown. Reaction during empty stomach is faintly alkaline. *Throughout its entire extent it is covered by* epithelial tissue, and is mostly composed of glands. With the aid of hand-lens the depressions are seen, and in each of these minute pits the mouths of gastric glands are visible.

The mucous coat is lined by a single layer of columnar epithelium with secreting glands. The glands are of two kinds, *viz*, (1) PYLORIC GLANDS, (2) CARDIAC GLANDS.

1 PYLORIC GLANDS.—They are tubular in character, and are most numerous at the pyloric end. They consist of two or three short, closed tubes opening into a common duct, the external orifice of which is situated at the bottom of little pit. The tubes and ducts are lined with epithelium. The duct is lined by columnar cells, continuous with the epithelium lining the mucous membrane of the stomach. The tubes are lined with shorter and more cubical cells. As they approach the duodenum the pyloric glands become larger. During secretion they become granular. They secrete pepsin only.

2 CARDIAC GLANDS.—They are found throughout the whole of the cardiac half and fundus of the stomach. They are tubular in shape. Two or three tubes open into one duct. The duct is short, is lined with columnar epithelium. In these glands there are two kinds of cells:—

(1) PARIETAL CELLS.—They are found between the epithelium and the basement membrane. They are large spheroidal, coarsely granular cells giving beaded appearance. They are supposed to secrete hydrochloric acid.

(2) CHIEF or CENTRAL CELLS.—These cells are finely granular, angular occupying the terminal tubes. They secrete pepsin.

These cells rest on a besement membrane Between the mucous membrane and the submucous coat is the muscularis mucosæ

BLOOD VESSELS, LYMPHATICS AND NERVES — Arteries divide and sub-divide in the mucous membrane, and then pass up between the tubuli and form a fine capillary plexus on their walls The veins pass in a similar manner backwards

THE LYMPHATICS —They arise by a fine network of vessels in the mucous membrane, and amongst the tubules, they then pass into a fine plexus just beneath the glands, pierce the muscularis mucosæ, and form another network in the submucous coat

THE NERVES —A plexus of nerves from the vagi and sympathetic through the solar plexus exist in the muscular coat and another in the submucous coat The sympathetic is vaso-motor nerve of the stomach, and the vagus is motor, sensory and secretory nerve

FUNCTIONS OF THE STOMACH

The stomach receives the bolus, and secretes the *gastric juice*, which acts on certain constituents of the food, while by its muscular walls it moves the latter within its own cavity, and after a time expels the partially digested products or chyme towards the duodenum

GENERAL PROPERTIES OF THE GASTRIC JUICE

PHYSICAL —The gastric juice is thin, clear, colourless fluid with a strong acid reaction, sour taste Its specific gravity is 1,005, and it contains only half per cent of solid constituent The quantity secreted in twenty-four hours varies, an average being 13 lbs It acts as an antiseptic

CHEMICAL CONSTITUENTS

1	Pepsin	0 32 per cent
2	Free hydrochloric acid	2 to 3 ,,
3	Rennin—a milk-curdling ferment	

4 Salts (chiefly sodium and potassium chlorides, and the compound of phosphoric acid with lime, magnesium, and iron)

5 Mucin

6 Water 99 44 per cent

(1) PEPSIN —This is an albumenoid substance of the nature of a hydrolytic ferment, it is soluble in dilute hydrochloric acid or glycerine This ferment in acid medium dissolves proteids, transforms proteids into *peptones* It has no action on fat, but dissolves envelopes of the fat globules

(2) FREE HYDROCHLORIC ACID —The acid occurs as free hydrochloric acid During digestion various organic acids appear—acetic, malic, lactic, and butyric The last two are formed by the fermentation of sugar to some extent during digestion, and this may be stopped by giving dilute sulphuric acid The acid reaction of the juice is due to the presence of hydrochloric acid

(3) RENNIN OR MILK-CURDLING FERMENT — It acts on casin It coagulates the casenogen

CHANGES OF THE CELLS DURING SECRETION

1. CARDIAC GLANDS —Before secretion the central cells are pale and finely granular During digestion they become swollen, enlarged and more coarsely granular

The granules are discharged into the lumen of the gland The granules are the precursors of the pepsin termed *pepsinogen*, which is converted into pepsin The parietal cells become enlarged and project more on the outside of the gland, and after secretion they become shrunken and they secrete hydrochloric acid

2 PYLORIC GLANDS —The cubical granular cells become more granular and enlarged During digestion lose granules and become smaller

THE CONSTITUENTS FORMED.

THE PEPSIN is produced by the pyloric glands and by the central cells

THE ACID is probably produced by the parietal cells Free Hcl is detected in gastric juice within forty-five minutes to one or two hours after a meal

THE CAUSE OF SECRETION

The secretion of the gastric juice is not constant When the stomach is empty there is no secretion of gastric juice This only takes place when the mucous membrane is stimulated In normal condition, secretion begins immediately on the introduction of food The mucous membrane becomes red, and the circulation more active, so that venous blood becomes brighter The mucous membrane may be stimulated to secrete the juice in the following ways —

1 MECHANICALLY —Stimulate the mucous membrane with a feather or glass rod The presence of food is the normal stimulus

2 CHEMICALLY —Ether, alcohol, dilute alkalies, pepper, and mustard

3 Agreeable emotions stimulate the flow, hence the presence of jesters or music during dinner

4 The sight or smell of food cause secretion

5 In fever secretion is diminished.

PROCESS OF GASTRIC DIGESTION.

There are three actions of the stomach in the process of digestion to complete normal digestion, and interference in any of these become pathological

The secretion of gastric juice and its action on food.

2. The absorption of the products of this digestion.
3. The movements of the stomach itself.

ACTION OF GASTRIC JUICE

It converts proteid of food into peptone, and also it acts as an antiseptic. The organism swallowed with the food are destroyed, and thus the putrefaction is prevented in the stomach

ACTION ON PROTEID —Pepsin and dilute hydrochloric acid at the temperature of the body transforms proteids by a process of hydration into a soluble and diffusible form called "Peptone" There are certain intermediate steps in this process

Fibrin first swells up and becomes transparent, and then falls into flakes It is stated that the first product formed during the gastric digestion of proteids is syntonin or para-peptone, then hemi-albumose or pro-peptone, and finally peptone.

According to Kuhne, the proteid molecule contains two preformed substances in its composition anti-albumen and hemi-albumen Gastric juice at first converts them into anti-albumose and hemi-albumose, and ultimately the former is converted into anti-peptone, and the latter into hemi-peptone Only the latter is capable of being split up by trypsin into lucin and tyrosin by the action of the pancreatic juice The following scheme represents the result —

Gastric Juice + Proteids
|
Albumen
|
Acid-albumen
|
Anti-albumen | Hemi albumen
Anti albumose | Hemi-albumose
Anti-peptone | Hemi peptone

PEPTONE

This is the final product of the action of gastric juice on proteid of food.

PROPERTIES OF PEPTONE

(1) It is insoluble in strong alcohol

(2) It is soluble in water.

(3) It diffuses very easily through the pores of animal membranes

(4) It is not precipitated by heat or nitric acid, acetic acid, potassium ferro-cyanide (unlike albumen).

(5) It is precipitated by tannic acid, mercuric chloride

(6) It gives a pink colour on the addition of caustic potash and a trace of cupric sulphate

(7) After absorption from the intestinal canal, the peptone is not found in the blood It seems to be reconverted into some other proteid as they pass through the mucous membrane of the intestine towards the blood. By giving peptones (instead of albumen) as food, life can not only be maintained, but there may even be an increase of body-weight.

ACTION OF THE GASTRIC JUICE ON VARIOUS FOODS

MILK is first coagulated by the milk-curdling ferment, after this it is dissolved and converted into peptone in the usual way

There is lactic acid ferment present in the gastric juice, which changes milk-sugar into lactic acid Part of the milk-sugar is changed in the stomach and intestine into grape-sugar

CARTILAGE is converted into a chondrin-peptone, and a body which gives the sugar-reaction

ELASTIC TISSUE, Epidermic tissue, mucin, nuclei are not digested at all

WHITE FIBROUS tissue is converted into gelatine, but gelatine is not converted into peptone in the usual way, so that feeding on gelatine means starvation

Coagulated albumen, if minutely subdivided, is more easily digested than raw Milk is not affected by boiling for digestion Meat is more digestable by boiling or roasting if not over-done

Fat and starch are not affected by the gastric juice, but the fat envelopes are dissolved and the fat thus set free. The starch is not affected by the juice, as it is too acid

Vegetable fats are not affected by the gastric juice

Cane-sugar is partly converted into grape-sugar, probably due to a ferment in the mucous.

Gluten (vegetable proteid) is digested in the same way as the animal proteid

CONDITIONS AFFECTING GASTRIC DIGESTION.

1. The nature of food

2 The amount of the food

3 The state of subdivision of the food
(Food should be well masticated)

4 It goes on best in the absence of mental and muscular exertion

5 Food at regular times, as the stomach must have rest

6 Weak digestion may be aided by a little dilute alcohol or bitter substances, also by liquor pepticus or dilute hydrochloric acid, before a meal

7 Alkalies disturb digestion, because they neutralise the acidity of the gastric juice. But small quantity of NaCl increases the secretion

8 Sleep retards digestion.

9 Copious draught of cold water disturbs digestion

10 Violent muscular exercise disturbs digestion

11. Menstruation retards gastric digestion

CHYME —The gastric digestion changes the food into a grey fluid, and this is called "Chyme" After three hours the pylorus opens, and chyme is discharged into the duodenum There the acidity is neutralised by the pancreatic juice Part of the pepsin is reabsorbed, and is found in traces in the urine and muscle juice

GASES IN THE STOMACH —The stomach always contains a certain quantity of gas, derived partly from the gases swallowed with the saliva, partly from gases which pass backward from the duodenum

Abnormal development of gases occurs in persons suffering from gastric catarrh, when gastric contents are neutral in reaction, Co_2 and H are produced by butyric acid fermentation.

THE MOVEMENTS OF THE STOMACH.—During digestion the contents of the stomach are kept in rotatory motion by the peristaltic action of its walls The food travels along the large curvature and returns by the lesser, or along both curvatures, and then returns along the centre of the viscus, thus currents are set up in this way By these movements the contents are moistened with gastric juice The other kind of movement consists of forcing the contents into the duodenum This begins after a quarter of an hour, and recurs until about five hours after a meal This movement is marked towards the pyloric end so as to relax the sphincter At the end of the process of digestion, the pylorus is permanently opened, and the chyme passes freely into the duodenum.

THE TIME OCCUPIED FOR GASTRIC DIGESTION.

In ordinary condition it may take four or five hours to complete the digestion of a meal in the stomach But the variation depends on the quantity and quality of the food and the state of body and mind of the person.

WHY IS THE WALL OF THE STOMACH NOT DIGESTED?

There are various theories—

1 The alkalinity of the blood protects the walls from being attacked by the acid (*Pavy*)

2 The thick layer of mucus protects the walls from the action of the gastric juice (*Bernard*)

3 The vital activity of the tissue resists the action of the juice If this vitality be diminished, the walls may be digested, the same as any other dead tissue, *e g*, in *post-mortem* digestion, or where a part is cut off from the circulation, as in thrombosis of one of its small blood-vessels, thus gastric ulcer may result Hot tea or any fluid destroys the vitality of the mucous membrane causing dyspepsia

VOMITING MECHANISM—It is a reflex act. At first there is salivation and nausea, then a deep inspiration is taken and the glottis closed to fix the diaphragm and press it against the stomach The walls of the stomach contract in peristaltic waves, running from the pylorus to the cardiac end, the œsophagus is shortened, and the sphincter is suddenly opened, the muscles of the abdominal wall contract, and the stomach, being fixed by means of the diaphragm, the contents are forced into the œsophagus the mouth is opened, and just as the contents are coming up there is an additional expiratory movement which prevents the food from entering the glottis and sends it through the mouth and nose

INFLUENCE OF NERVES—The centre is placed in the medulla oblongata, in the neighbourhood of the respiratory centre

THE AFFERENT NERVES—These depend on the cause —

(1) The mucous membrane of the soft palate, pharynx, root of the tongue—Glasso-pharyngeal nerve (as in tickling the fauces or posterior part of the tongue).

(2) The nerves of the stomach, vagus and sympathetic (as in cases where the contents of the stomach are the exciting cause, or from an unhealthy state of its walls)

(3) Stimulation of the uterine nerves (as in pregnancy)

(4) The mesenteric nerves (inflammation of the abdomen and hernia)

(5) Nerves of the urinary apparatus (as in passing renal calculus).

(6) Nerves of the liver and gall-bladder—vagus (as in passage of gall-stones).

(7) Nerves to the lungs—vagus (as in phthisis).

(8) The first cranial nerve (as from disagreeable smells).

(9) The second cranial nerve (as from disgusting sights).

(10) The nerves of taste

(11) Vomiting is also produced by direct stimulation of the vomiting centre (as by subcutaneous injection of apomorphia)

(12) Cerebral (as a tumour in the brain)

THE EFFERENT NERVES are—Vagus (stomach and œsophagus), phrenics (diaphragm), intercostals (abdominal muscles)

WATER APPETITE OR THIRST

The sensation of thirst is usually referred to dryness of the mouth, tongue and fauces, it is not due to that alone, for the mouth may be dry and yet no thirst This dryness

may be allayed by eating substances which excite the secretion of saliva

The sensation of thirst is chiefly due to deficiency of water in the blood, inject water into the blood, it is allayed, though when taken by the mouth, the effect is more marked and lasting If water is withheld too long—delirium, mania and death may result Abnormal thirst occurs—in excess of saline matters in the blood, hæmorrhage and in most fevers

HUNGER APPETITE —It is partly due to emptiness of the stomach, and may be allayed for a time by introducing even indigestible substances as clay, etc It is chiefly due to the state of the blood or perhaps rather to the state of the tissues wanting certain substances that the blood is unable to supply If the vagi be cut, the sensation is still felt, in this the sensation cannot come from the stomach, but must arise in the central nervous system, probably from cells near the root of the vagus That it is due to the state of the blood is shown by the fact that if enemata be injected into the bowel, or nutrient material into the blood directly, the feeling is allayed Food cannot be done without longer than three weeks It is dangerous to eat too much after starvation, as the gastric glands are too weak to secrete, so it is a safe rule to begin with peptonised food

WANT OF APPETITE may depend on mental causes, as joy, anger or anxiety, or it may appear without any cause

EXAMINATION OF THE GASTRIC CONTENTS —

When it is desired to ascertain whether gastric digestion is normal, a test meal is first given, then a portion of the gastric contents are pumped out at various intervals through an elastic œsophageal tube, and chemically examined.

TEST FOR ACIDS —Take the filtered gastric contents, add to it a solution of congo-red, it becomes blue Wash in æther, and, if the red colour be restored, the acid is organic, if not, the acid is mineral, and therefore Hcl In gastric catarrh and in cancer of the stomach, the secretion of Hcl is diminished

UFFLEMAN'S REAGENTS is a most convenient one for general practice The reagent is made by colouring a 1 per cent solution of carbolic acid by the addition of tinct Ferri perchlor

METHOD —Take filtered gastric contents, add an equal quantity of the reagent

If Hcl is normal—colour is discharged
If lactic acid be present—canary yellow
If butyric acid be present—dirty grey

Another delicate test for Hcl is an alcoholic solution of vanillin and phloro-glucin Add this solution to the gastric contents, and then evaporate, a brown-pink residue is left

TEST FOR PEPTONE (*Vide above*)

(1) Gives xanthopratic reaction
(2) Gives a pink colour reaction with copper sulphate

PRESENCE OF PEPSIN —The presence of pepsin can be ascertained by the following process —Take a filtered solution of the gastric contents, add to it 0 2 per cent of Hcl, place in this solution boiled fibrin—the fibrin will be dissolved as in normal gastric juice

VOMITED MATTERS may be tested in a manner similar to the above, in addition to that also require microscopic examination

PHYSICAL EXAMINATION OF THE STOMACH

INSPECTION —Note to the state of viscus There is nothing to be seen in the normal condition

PERCUSSION —When stomach is not distended with food, a tympanitic sound may be elicited In some cases

a difference in the pitch or quality of the note indicates that we have passed from the stomach to the colon

PALPATION —When the stomach is the seat of ulceration or malignant growth, there may be pain or tenderness on pressure Evidence of dilatation of the stomach is obtained by producing a splashing sound in it This is done by placing both hands over the organ, and pressing it inwards, and making a movement as if shaking the organ from side to side

The limit of dilated stomach can also be ascertained by giving first a solution of tartaric acid, then a solution of bicarbonate of soda

INTESTINAL DIGESTION

(INCLUDING PANCREAS, LIVER, INTESTINE)

PANCREAS —It is long, narrow, and flattened, and lies obliquely across the posterior wall of the abdomen behind the stomach It has a duct called duct of Wirsung and runs along the whole length of the gland. It opens, along with the common bile-duct, into the duodenum

STRUCTURE —It is tubular gland resembling the parotid It has a fibrous capsule which sends inward septa to divide the gland into lobes and lobules, and the main duct is called lober ducts

So we have—

(1) Wirsung duct
(2) Lober ducts—then
(3) Lobular ducts—which end in
(4) Intermediate ducts—and these end in
(5) The ACINI

The single layer of cylindrical epithelium lines the ducts

The acini are lined by a single layer of cylindrical cells These consist of two zones

(1) Outer or parietal zone somewhat striated, and (2) the inner zone is granular

THE CELLS DURING SECRETION—*the* granules of the inner zone during the secretion are discharged, thus the outer zone becomes wider and the inner zone narrower

These granules are the precursor of trypsin called *trypsinegen* or *zymogen*

SECRETION OF THE PANCREATIC JUICE

It is not constant, it begins soon after food is introduced into the stomach, and continues all the time that the food is there, and for one or two hours after it has passed into the duodenum The maximum rise occurs just after food is taken, then there is a fall, and again a slight rise when food passes into the duodenum It is usually obtained from the dog by means of pancreatic fistula

CHARACTER OF THE PANCREATIC JUICE

PHYSICAL—It resembles saliva It is clear, viscid, strongly alkaline fluid It contains a large quantity of carbonate of sodium The alkalinity is due to this salt Sp gr 1010 to 1015 At first it does not contain leucin, but if it stands, then *leucine* and *tyrasine* appear The chief action of the juice is *emulsification* and *saponification* of fat The daily amount secreted is twelve to sixteen ounces

CHEMICAL.

1 Water

2 Organic matters as—

(*a*) Albumens,—serum-albumen, alkali-albumen

(*b*) Ferments are four—

(1) A fat-splitting ferment (steapsin)

(2) A sugar-forming ferment (amylopsin)

(3) A peptone-forming ferment (trypsin)

(4) A milk-curdling ferment (rennin)

3 SALTS—Carbonate of sodium, chloride of sodium, and potassium, phosphate of calcium, magnesium, and sodium

ACTION OF THE PANCREATIC JUICE.

The presence of four ferments makes the juice one of the most important digestive fluids in the body

1 A SUGAR-FORMING FERMENT —It converts starch into maltose even more rapidly than the saliva, and will act even on unboiled starch

2 A PEPTONE-FORMING FERMENT —Changes proteids into peptones, and further effect changes peptones into the leucin and tyrosin

3 A FAT-SPLITTING FERMENT this *emulsifies* and *saponifies* fats This is the great action of the pancreatic juice It decomposes the neutral fats into glycerine and fatty acids

The fatty acids thus liberated are partly saponified by the alkali of the pancreatic and intestinal juices, and partly emulsionised by the alkaline intestinal juice Both the soaps and emulsion are capable of being absorbed

EMULSION —It consists of a very minute sub-division of the fatty matters If the fat to be emulsified contain a free fatty acid, and it is mixed with alkaline, emulsification takes place rapidly

The most important changes takes place in the small intestine, it is the production of an emulsion This is necessary in order that the fats may be absorbed by the lacteals

When the flow of pancreatic juice is arrested by tumour or any other cause, the fat is not absorbed It passes with fæces Consequently the juice facilitates in absorption of fat

ACTION OF PANCREATIC JUICE ON PROTEID

The trypsin of pancreatic juice converts the proteid into peptone in an alkaline medium, not with the aid of any acid like pepsin It acts more rapidly than pepsin, but similar intermediate stages are produced in the formation

of peptone. After intermediate stages, hemipeptone is formed, and when trypsin is allowed to act upon it longer, it is changed into leucin, tyrosin, hypoxanthin, xantin, aspartic acid, and ammonia If the action of the juice is still further prolonged, a body with disagreeable fæcal odour is formed together with indol, skatol and phenol

The following scheme represents the action of the trypsin of pancreatic juice on proteid —

Pancreatic juice + albumen
|
Alkali-albumen
|
Anti-albumose | Hemi-albumose
| |
Anti-peptone | Hemi-peptone
|
Leucin
Tyrosin

It has been shown that removal of the pancreas in animals and diseases of the pancreas in man produce diabetes

PEPTONISED FOOD —Peptonised food may be given to persons whose digestion is feeble Food may be peptonised either by peptic or tryptic digestion But tryptic to be preferred to peptic for peptonising foods, because that peptonised by peptic digestion has a very disagreeable taste, and whereas that by tryptic digestion has not

PEPTONISED MILK —Take a pint of milk and dilute it with a quarter of a pint of water and heat it to 60°C Add a tablespoonful of liquor pancreaticus (BENGER), and 20 grains of bicarbonate of soda are then mixed therewith Keep the mixture at 38°C for about two hours, and then boil it for two or three minutes, which arrests the further digestion

PEPTONISED MILK—GRUEL —It is a highly nutritious food for a weak digestion Make a thick gruel of

oatmeal or any farinaceous food in the usual way, and boil for a few minutes. Then add an equal volume of cold milk to it, then a tablespoonful of liquor pancreaticus, and 20 grains of bicarbonate of soda. Keep warm under a tea cosy for two hours, and then stop further digestion by boiling for a few minutes.

PEPTONISED BEEF-TEA.—Half a pound of minced beef, half a pint of cold water, and 20 grains of bicarbonate of soda are mixed together, and allowed to simmer gently for an hour and-a-half, and then cooled to about 100° F. A tablespoonful of liquor pancreaticus is then added and the mixture kept at about 100° F. for two hours; it is then strained and boiled for five minutes.

THE LIVER

ANATOMICAL POSITION.—Its superior surface is in contact with the diaphragm. Its anterior, posterior, and lateral aspects are in contact with the ribs and the abdominal wall. Superiorly it reaches the level of the lower border of the fourth rib. Its inferior limit coincides with the lower edge of the ribs, except in the epigastrium.

THE CAPSULE.—The liver is covered by a thin, fibrous, firmly-adherent capsule. The capsule sends inward septa dividing the organ into lobes. At the transverse fissure it becomes continuous with a sheath of areolar tissue that surrounds the branches of the *portal vein*, *hepatic artery*, and *bile duct* as they ramify in its substance. This is known as "Capsule of Glisson." The spaces in which these three structures lie are known as portal canals.

LOBES.—The liver is made up of lobes, and these again are composed of lobules closely packed one upon another. Each lobule consists of cells compactly arranged around branches of the hepatic vein (= intra-lobular vein), and lobule rests on a vein by its base (= sub-lobular vein) into which the central vein of the lobule opens. Each lobule is thus penetrated from the circumference by a close network

of capillaries, and the minute beginnings of the bile ducts The circumference of the lobule is surrounded by the inter-lobular veins which are branchlets of the portal vein In each lobule we find four networks —

(1) Of hepatic cells
(2) Of blood-capillaries
(3) Of bile-capillaries
(4) Of nerves.

THE HEPATIC CELLS —The cells are the secreting part of the liver, they are in shape rounded or polygonal They have a yellow granular appearance, and well-marked prominent nucleus, there is an inter-nuclear network and an exceedingly dense interprotoplasmic network There is a very thin delicate cell-wall They are held together by a very delicate sustentacular tissue, which contains fine channels for bile-capillaries.

The cells are arranged in a network of anastomosing columns

CHANGES IN CELLS —The appearance of the cells varies with the period of digestion

DURING HUNGER—the cells are finely granular and cloudy, and contain little glycogen and nucleus is absent

DURING DIGESTION—the cells are larger and more distinct, and contain minute oil globules and glycogen

BLOOD VESSELS OF THE LIVER

THE PORTAL VEIN —It is formed by the union of the *splenic, inferior* and *superior mesenteric veins* It enters the liver at the transverse fissure, accompanied by the bile-duct and hepatic artery, and is distributed between the liver lobules The portal vein returns the blood from the *stomach, pancreas, intestines,* and *spleen*, hence it carries some of the products of digestion directly to the liver The portal vein after its entrance into the liver subdivides into branches that ramify *between* the lobules and anastomose freely, and ultimately form small trunks

which reach the periphery of the lobules The branches of the portal vein lying between the lobules are called the *interlobular* veins From these veins numerous capillaries are given off into the substance of the lobules The capillaries converge towards the centre of each lobule, where they join to form one large vein, hepatic vein

HEPATIC VEIN —It begins in the centre of the lobules It traverses each lobule, reaches its surface at one point, passes out, and joins similar veins from other lobules to form sub-lobular veins, and these again unite to form hepatic venous trunk, and these unite and pass to the posterior border of the liver and end in the inferior vena cava The walls are very thin and firmly adherent to the liver substance, and they have no valves

HEPATIC ARTERY —It is chiefly nutritive to the connective tissue It ends in three sets of branches—

(1) VAGINAL, to supply the walls of the ducts and vessels and "glisson capsule"

(2) CAPSULAR, to fibrous coat of liver

(3) INTER-LOBULAR twigs, that ramify chiefly in the middle zone of the lobule Thus lobules are divided into *three* zones—

(1) Peripheral—Portal vein capillaries
(2) Middle—Portal vein and hepatic artery capillaries
(3) Central—Hepatic vein capillaries

THE BILE-DUCTS —The finest bile capillaries arise at the centre of the lobule They commence in a fine plexus of bile-capillaries which run between and surround each individual liver cell forming the lobules of the liver. From the lobules they pass to the interlobular plexus, and then join with each other to form the larger ducts, and finally leave the liver and meet with the cystic duct to form common bile duct which opens into the duodenum The larger bile ducts are lined with columnar epithelium, their coats being formed of fibrous tissue with many elastic

fibres, with a mixture of non-striped muscular tissue as well as in the larger ducts In the larger ducts there are many mucous glands which secretes mucous of the bile

NERVES OF THE LIVER —The nerves come from the solar plexus and the left vagus, the branches pass along with the hepatic artery, the vagus is sensory, the sympathetic is vaso-motor

THE GALL-BLADDER is a bag lying under surface of the liver, which retains the bile during the intervals of digestion It is composed of three layers, serous and fibrous coats, internally lined by mucous membrane which presents honeycombed appearance It is provided with mucous glands like biliary ducts

FUNCTIONS OF THE LIVER

Will be considered briefly under four heads—

(1) The manufacture of bile (to secrete bile)

(2) The metabolism of carbo-hydrate (Glycogenic function of the Liver)

(3) Metabolism of proteid material (Urea uric acid forming function which will be discussed under the urine)

(4) As a source of heat and energy to the body generally

THE MANUFACTURE OF BILE

The bile is secreted continuously, and it is poured in increased quantity into the intestine on the arrival of food in the duodenum In the interval it is carried along the cystic duct and stored up in the gall-bladder

CHARACTERS OF THE BILE

PHYSICAL —Bile is a brownish-yellow fluid It has an alkaline, bitter taste, and specific gravity 1018 The bitterness is due to bile acids, and alkalinity due to alkaline phosphate

CHEMICAL COMPOSITION

1	Water	85.92
2	Bile acids	9.14
3	Fat	0.92
4	Cholesterine	0.28
5.	Mucin and pigments	2.98
6	Inorganic salts, sulphate of calcium, iron phosphate, chloride of sodium	0.78

BILE ACIDS ARE—

(1) Glyco-cholic acid
(2) Tauro-cholic acid—the chief

These acids are united with soda to form glyco-cholate and tauro-cholate of soda, which have a bitter taste In human bile tauro-cholic acid is most abundant, and contains sulphur and glyco cholic acid is abundant in carnivorous animals This is a most important difference between the two acids When these acids are boiled with caustic potash or dilute mineral acids—

1 Glyco-cholic acid takes up water, and splits into—
(1) Glycocine
(2) Cholalic acid—thus

Glyco-cholic acid = cholic acid + glycocin

$$C_{26}H_{43}NO_6 + H_2O = C_{24}H_{40}O_5 + C_2H_5NO_2$$

2 Tauro-cholic acid also takes up water and splits into—
(1) Cholalic acid
(2) Taurin—thus

(Tauro-cholic acid = cholic acid + taurin)

$$C_{26}H_{45}NSO_7 + H_2O = C_{24}H_{10}O_5 + C_2H_7NSO_3$$

Glycocin—is amido-acetic acid—

$$[C_2H_2\ (NH_2)\ O\ (OH)]$$

Taurin—is amido—ethyl-sulphuric acid—

$$[SO_2\ (OH)\ (C_2\ H_4\ \{NH_2\})\ ]$$

Bile acids are produced from proteid in the liver because both contain nitrogen They are not found in blood, when food is rich in proteid the production of bile acids

are increased If common bileduct be tied, then bile instead of being secreted will be absorbed by the liver and will enter into the circulation In that case bile can be detected in blood

FATE OF BILE ACIDS

They are to a small extent excreted in the fæces Taurocholic acid is not found, because it is decomposed into cholalic acid and taurin Most of the acids are re-absorbed from the alimentary canal, and pass to the liver again by the portal vein This is proved by analysing the fæces, they contain about one-eighth of the daily amount of sulphur secreted by the liver, so that about seven-eighths are re-absorbed, probably in the form of taurin, and pass back to the liver, to be perhaps again reconstructed into its former compound

PETTINKOFER'S TEST FOR THE BILE ACIDS

To dilute bile add a few drops of a solution of cane-sugar, and after that some strong sulphuric acid, the solution becomes violet colour

(Bile + sugar + H_2SO_4 = violet)

CHOLESTERIN

It is the only free alcohol found in the body under normal conditions, and is composed of carbon, hydrogen, and oxygen It is insoluble in pure water, but is held in solution by the bile salts, it sometimes becomes precipitated and forms gall-stones It is soluble in ether, chloroform, and boiling alcohol It occurs in white crystals, usually in the form of rhombic plates, very often with a bit out of one corner

TEST

With strong sulphuric acid, and a trace of iodine, it becomes a violet colour, which afterwards changes to green and then red

SOURCES OF CHOLESTERIN

It is purely an effete matter It is abundantly found in the white of nerve tissue It is obstructed from the blood by the liver The liver is the only channel by which it is excreted

MUCIN —The mucus is secreted by the general epitheleum and mucous glands of the larger bile-ducts and gall-bladder—especially the latter This makes bile sticky

TEST

It is precipitated by acetic acid

THE BILE PIGMENTS

1. Bilirubin—The yellowish-brown colour of the bile is due to this pigment It is an iron-free derivative of hæmoglobin The iron is stored up in the liver cells

2 Biliverdin—is a green pigment It is an oxidised derivative of bilirubin When treated with oxidising agents, bilirubin takes up oxygen and becomes biliverdin

GMELIN'S TEST FOR BILE PIGMENTS

Add to bile fuming nitric acid, *i e*, nitric acid holding in solution some nitrous acid gives a play of colours—green, blue, violet, red—ending with yellow It is best done by placing a drop of the liquid on a white porcelain plate, and adding a drop of the impure nitric acid

SOURCE OF THE BILE PIGMENTS

It is supposed that the pigment is derived from the hæmoglobin of the blood The red blood corpuscles are destroyed in the spleen and the hæmoglobin set free, and carried by the portal vein to the liver

INORGANIC SALTS OF THE BILE

There is much sodium chloride, also some sulphate of calcium, and some phosphate of iron

Amongst the other organic constituents is lecithin

SECRETION OF THE BILE

The bile is secreted continuously, though it is not always flowing into the intestine The part is stored up in the gall-bladder, and is poured out copiously during digestion The secretion is especially active during digestion When the food from the stomach passes over the orifice of the bile duct, a gush of bile takes place There is rapid rise after meals, reaching its maximum in from four to ten hours. There is then a slight fall, afterwards a slight rise The daily secretion is about forty ounces

INFLUENCE OF VARIOUS FACTORS ON THE SECRETION OF BILE

1 THE CENTRAL NERVOUS SYSTEM —In some unexplained way it has the influence on the secretion of bile, as the sudden appearance of jaundice from fright

2 DIET —The secretion is greatly influenced by quality and quantity of the food taken The largest amount is secreted after a flesh diet, great increase when liver is used as an article of diet Less with vegetable food, it stops during hunger Draughts of water increases the amount

3 EXERCISE—which is not associated with perspiration increase the secretion of bile

INFLOW OF THE BILE INTO THE INTESTINE

It is important to distinguish between the bile-secreting and the bile-expelling mechanism

(1) The bile-secreting mechanism depends upon the liver cells, which are always in some degree in activity

(2) The bile-expelling mechanism, which is especially active at certain periods of digestion

THE INFLOW DUE TO—

(1) Pressure of the secretion

(2) The contraction of the muscles of larger bile-ducts and the gall-bladder

(3) Extraneous muscular compression, *e g*, muscular exercise causes flow of bile into the intestine, the liver is like sponge, and the bile is squeezed out

FUNCTIONS OF THE BILE

(i) It plays a part in digestion
(ii) Part of it is excreted
(iii) Part of it is re-absorbed

I IT PLAYS A PART IN DIGESTION

(1) It assists the absorption of fatty matters —

(*a*) It emulsifies fat by helping the pancreatic juice, whereby the fatty granules pass more readily through the lacteals It does not decompose fats into glycerine and a fatty acid as the pancreas does

(*b*) It facilitates the passage of oily matters easily through the capillary tubes, when mucous membrane is moistened with bile

(2) Fresh bile contains a drastic ferment which transforms starch into sugar, and also glycogen into sugar

(3) It stimulates the muscular fibres of the intestine, and causes the villi to contract reflexly, and thus pump or squeeze out the absorbed fatty matters into the underlying lacteals

(4) It reflexly stimulates the muscular coat of the intestine to contraction acting as natural purgative

(5) It acts as an antiseptic—by diminishing putrefactive decomposition of the intestinal contents, especially with a fatty diet

(6) Bile moistens the wall of the intestines, and gives to the fæces their normal amount of water, so that they can be readily evacuated

II PART OF IT IS EXCRETED

(1) Mucin passses unchanged into the fæces
(2) The bile pigments are excreted partly with fæces as hydro-bilirubin, and partly excreted by the urine as urobilin
(3) Cholestrin is excreted with fæces as stercorin

III PART OF IT RE-ABSORBED

Most of the bile acid, especially taurin and its allied substance, i e, sulphur-containing substance

BILIOUSNESS

It may be due to defective activity of the liver, and the consequent non-withdrawal of bile pigment from the blood, but is more likely to be due to—

2 A catarrhal condition of the bile ducts, impeding the exit of the secreted bile, and so causing its absorption into the blood It is very easily absorbed, as the secreting pressure is low

JAUNDICE—is the name applied to a group of symptoms arising from absorption of bile due to obstruction in the inflow of bile in the intestine When due to obstruction, bile accumulates in the excretory ducts, and passing backwards into the lymph enters the blood, and thus causes yellow tint in the skin

SYMPTOMS.

(1) Yellowish tint

(2) Bile pigments and bile acids in the urine, giving the colour of urine yellowish brown

(3) The fæces are clay-coloured, because the hydrobilirubin is absent from the fæcal matter, and very hard (because the fluid of bile does not pass into the intestine), contain fat and very disagreeable odour.

(4) The heart beats are slowed as bile salts weaken the heart

(5) The nervous system and muscles are also affected, is shown by the signs weakness, drowsiness, deep coma, sleeplessness, itchiness of the skin, even mania and spasm

ACTION OF LIVER ON ALBUMINOUS SUBSTANCES

The circulating albumen—i e, which has played its part

in the economy and is now unfit for further use, is broken up in the liver into—

(1) Glycogen

(2) Fatty acids, which are oxidised to carbonic acid and water, and escape by the lungs

(3) Nitrogenous substances—as urea, uric acid, these re-enter the circulation, and are eliminated by the kidneys

GLYCOGENIC FUNCTION OF THE LIVER

This means transformation of sugar of the blood of the portal vein into glycogen, and storage of it into the centre of hepatic cells The sugar absorbed from the alimentary canal disappears and glycogen appears It is also called animal-starch

PRODUCTION OF GLYCOGEN

It is produced during the absorption of food by the metabolic activity of the hepatic cells (=glycogenic function of the liver), glucose is the chief sugar, found in the blood of the portal vein which passes to the hepatic cells where it gets dehydrated and becomes glycogen It is represented thus—

Glucose = glycogen

$$C_6H_{12}O_6—H_2O=C_6H_{10}\ O_5$$

It is stored up in the hepatic cells during digestion, and is used up during fasting The storage of glycogen in liver cells may be demonstrated by the reaction of iodine on section of liver containing it which gives colour red

PREPARATION OF GLYCOGEN

Feed a rabbit on carrots and kill it five hours after. Rapidly excise the liver, and throw it into about 150 c c boiling water in a porcelain basin Cut the liver into small pieces with scissors in the boiling water After boiling for ten minutes strain through muslin, and filter through animal charcoal and paper The filtrate contains abundance of glycogen

CHARACTERS OF GLYCOGEN

Resembles both starch and dextrin, but differs from both, is colourless, tasteless, readily soluble in water, solution is opalescent like that of starch

TEST—Iodine gives red colour with it, which disappears on heating and re-appears on cooling

SOURCE OF GLYCOGEN

Glycogen is produced by the liver on following diet —

1 The chief source is carbo-hydrates

2 A small amount is produced from proteids

3 Fats do not produce glycogen This is peculiar, because glycogen is produced from sugar, fat can also be produced from sugar, but fat cannot be transformed into glycogen

Glycogen is found in liver, placenta, and in muscle protoplasm generally

DESTINY OF GLYCOGEN

Glycogen is gradually converted into sugar, and leaves the liver by the hepatic veins, and so supplies the systemic blood with sugar, which is constantly used up for the purposes of nutrition (Bernard)

It is rapidly changed into glucose after death by means of special ferment

ULTIMATE FATE OF GLYCOGEN

1 It is a source of muscular energy.

2 It leads directly to the production of fat

3 It may also, by its decomposition, assist in the production of heat

DIABETES

DIABETES INSIPIDUS—is the persistent discharge of pale urine of low specific gravity, containing neither albumen nor sugar

DIABETES MELLITUS —In this condition there is a persistent passage of grape-sugar in the urine, the urine is large in quantity, pale, and of high specific gravity When the normal amount of grape-sugar in the blood is increased, grape-sugar appears in the urine Claud Bernard advanced the theory that it is due to a fault of the liver, the conversion of glycogen into sugar was abnormally in excess, then the sugar accumulated in the blood, and was eliminated by the urine Further, he showed that by puncturing or irritating the eighth pair of nerves at their origin in the fourth ventricle, an abnormal development of sugar could be produced

Pavy produced diabetes mellitus artificially by sending a stream of arterial blood through the portal vein, and by hyperoxymation of the blood in the body generally The same thing occurs when the portal vein is tied, for then the liver is fed only by arterial blood—from the hepatic artery. He found there was much increase of sugar in the urine

THE CHANGES IN THE BLOOD AFTER PASSING THROUGH THE LIVER

The blood, in passing through the liver,

LOSES—

1 Albumen
2 Fibrin
3 Cholesterin
4 Blood-colouring matters
5 Red corpuscles

IT GAINS—

1 Heat
2 Urea
3 Uric acid
4 Glycogen or sugar

SMALL INTESTINE

The small intestine extends from the pyloric end of the

stomach to the large intestine Its length is about 20 feet It has three main parts—

1 The duodenum
2 The jejunum
3 The ileum

STRUCTURE

The wall of the small intestine consists of four coats, which are named from without inward serous, muscular, sub-mucous, and mucous

1 SEROUS OR EXTERNAL COAT—It has the structure of the peritoneum

2. MUSCULAR COAT—two layers—

(1) Outer longitudinal—but thin

(2) Inner circular—thicker layer of non-striped muscular fibres

Between the two layers is a nerve-plexus (Averbach's plexus)

(3) Sub-mucous—loose connective tissue and fine elastic fibres containing large blood-vessels, lymphatics and plexus of nerves,—Meissner's plexus

(4) Mucous membrane —This is the most internal coat and has a velvety appearance from the presence of villi It is covered by columnar epithelium Next the sub-mucous coat is the muscularis-mucosæ The following structures are found in the mucous coat —*valvulæ conniventes, villi,* and the *glands*

VALVULÆ CONNIVENTES

They are double folds of mucous membrane of the small intestine, arranged across the long axis of the gut They begin a little below of the pylorus and end about the middle of the ileum They are well marked in the duodenum Their service is to afford a largely increased surface for secretion and absorption.

VILLI

They are small processes of mucous membrane, about $\frac{1}{4}$ inch in length. They are very vascular, projecting from the mucous membrane of the small intestine throughout its whole extent They are confined exclusively to the mucous membrane of the small intestine They are largest and most numerous in the duodenum and jejunum, and grow smaller and are less numerous in the ileum

STRUCTURE OF A VILLUS FROM WITHOUT IN

1. Columnar epithelium with the clear hem, and some goblet cells here and there

2 Basement membrane, consisting of a layer of squamous endothelium

3 Retiform connective tissue, with spaces and clefts lined with squamous endothelium

4 A capillary network of blood vessels

5 A few longitudinal non-striped muscular fibres, at the apex of the villus these become continuous with the retiform fibres

6 A lacteal in the centre its wall is formed by squamous endothelium

FUNCTION OF VILLI

The villi absorb from the intestine diffusible substances like grape-sugar, peptones, and water, pass directly through the columnar epithelium and so into the blood-vessels Fatty matters are not diffusible, and so they pass through the interstitial clear cementing substance between the cells, and pass into the central lacteal, they do not pass through the striæ of the clear hem The longitudinal non-striped muscular fibres in the villi contract, shorten the villus, and squeeze out the contents, afterwards tho villus is elongated again by the blood pressure in the capillaries

GLANDS

There are only two secreting glands, those of Lieberkuhn and of Brunner Peyer's patches and the solitary glands are composed of lymphoid tissue

CRYPTS OF LIEBERKUHN

They are found all through both small and large intestines placed vertically like test-tubes in a stand In the small intestine they open between the villi In the large intestine they contain a great many more goblet cells than in the small

They are simple tubular glands, they have a basement membrane supporting columnar epithelium of the usual type, mixed with goblet cells for secreting mucin, beneath the basement membrane we find adenoid tissue

They secrete *intestinal juice* (succus entericus)

BRUNNER'S GLANDS

They are compound tubular glands lying in and confined to the sub-mucous coat of the duodenum, and their ducts perforate the muscularis mucosæ to open on the surface

These glands and crypts of Lieberkuhn's are only two intestinal glands that pour their secretion into the small intestine

SOLITARY GLANDS

They are small, oval masses of adenoid tissue They are placed in the sub-mucous tissue, but extend up and cause a slight bulging of the mucous membrane

They begin at the pyloric end of the stomach, and found throughout the whole small and large intestines They are masses of adenoid tissue loaded with leucocytes

PEYER'S GLAND OR PATCHES

They consist of groups of lymph-follicles lying side by side resembling the solitary glands in structure They are found chiefly at the lower end of the ileum, and become fewer in number as we approach the jejunum

BLOOD-VESSELS OF THE SMALL INTESTINE

The mesenteric arteries branches ramify under the serous coat They penetrate tho muscular coat giving branches, enter the sub-mucous coat and ramify therein.

LYMPHATICS OF THE INTESTINE

They are lacteals which begin in the centre of villi.

NERVES OF THE INTESTINE

They are derived from the superior mesenteric plexus—branches from the cœliac plexus, semilunar ganglia, and vagus Final branches pass—one set between the layers of the muscular coat and is called Auerbach's plexus, consisting of a close gangliated plexus From the branches pass to form a second richly gangliated plexus in the submucous coat, called Meissner's plexus

NOTE THE VARIOUS STRUCTURES IN THE INTESTINE

1. VILLI —They begin a little below from the pylorus to about the middle of the ileum, becoming fewer and smaller as they pass downwards

2 Brunner's gland—found only in the duodenum

3 Crypts of Lieberkuhn—in both small and large intestines

4 Solitary glands—in both small and large intestines

5 Peyer's patches—found chiefly at the lower end of the ileum, and grow fewer as we pass upwards towards the jejunum

THE SECRETION OF BRUNNER'S GLAND

When a part is isolated and a watery extract made from it, it is found that the juice can digest fibrin in the presence of hydrochloric acid It also converts maltose into glucose It has no action on fat

THE SECRETION OF LIEBERKUHN'S GLAND

This is the chief source of the intestinal juice It can be obtained by Thiry's method of artificial fistula.

CHARACTERS OF INTESTINAL JUICE

It is a thin straw-coloured, strongly alkaline fluid, specific gravity 1011, evolves CO_2 when an acid is added It contains albumen, mucin, ferments, and salts

ACTION OF THE JUICE

(1) It peptonises proteids, but not very rapidly

(2) It converts starch into dextrin and maltose

(3) It has *sugar-inverting* ferment, changing cane into grape-sugar

(4) It has a slight emulsifying power

(5) It assists the pancreatic juice to neutralise the acid

CHANGES IN THE CONTENTS OF THE SMALL INTESTINE

The contents become milky and alkaline after the action of pancreatic juice, bile and the succus entericus This milky substance is absorbed in the intestine by the lacteals The term chyle is applied to the contents of lacteals The putrefactive changes occur in the unabsorbed material by the presence of bacteria which are swallowed with the food and drink The contents acquire a fæcal odour at the lower end of the ileum

LARGE INTESTINE

STRUCTURE.

It has four coats, like those of the small intestine

1. THE SEROUS COAT is the same as in the small intestine, in addition to that it has little projection filled with fat called appendices epiploicæ.

2 THE MUSCULAR COAT

(1) The external longitudinal layer is collected into three flat longitudinal bands

(2) The internal circular layer is much the same as in the small intestine.

3 THE SUBMUCOUS COAT—like that of the small gut

4 THE MUCOUS COAT—is smooth no villi, no Peyer's patches, Lieberkuhn s glands are more numerous and contain very many chalice cells, and hence secrete more mucin The solitary glands occur throughout the entire length of the large intestine. In other points resembling the small intestine

CHANGES OCCUR IN THE LARGE INTESTINE

Within the large intestine, the fermentative and putrefactive processes are certainly more prominent than the digestive process, as only a very small amount of the intestinal juice is found in it

ABSORPTION is very great and active and absorption goes on even in the rectum, and on this depends the fact that we may feed a patient with peptonised foods per rectum Water and the products of digestion in solution are not the only substances absorbed, but under certain circumstances, unchanged fluid egg-albumen, milk and its proteids, flesh juice, myosin with common salt, may also be absorbed In the case of feeding by rectum, it does not matter much whether we use the liq pepticus or liq pancreaticus, nor need we destroy the ferment at a certain stage by boiling To the food to be given add the ferment, inject it into the rectum—the rectum acts as the "tea-cosy" The fæcal matters are formed or rather shaped in the lower part of the gut

DECOMPOSITION OF INTESTINAL CONTENTS

Decomposition of food is prevented in the stomach by the gastric juice Decomposition is prevented in the upper part of the intestine by taurocholic acid

As the intestinal contents move downwards, the acidity becomes neutralised, and as soon as they are alkaline bacteria begin their work

1 They decompose hæmepeptone into indol, skatol, phenol, volatile fatty acid and gases

2 They set up lactic acid fermentation on carbohydrates This is the chief cause of gases in the intestine, amount increased by vegetable food

3 They decompose fat into valeric and butyric acids. These acids give the contents acid reaction

The intestinal contents acquire fæcal odour from the lower part of the small intestine and the cæcum onwards

FÆCES

THE AMOUNT —It varies according to the diet The amount is less, after a diet of flesh and albumen, than after a vegetable diet If much indigestible food be taken, it may be much increased

THE CONSISTENCE—depends on the amount of water preseut The amount of water depends partly on the food—pure flesh diet causes dry fæces, while substances rich in sugar yield fæces with a large amount of water

THE REACTION—is often acid, due to acetic acid, lactic acid, butyric acid produced by the fermentation

THE ODOUR—which is stronger after flesh diet than after a vegetable diet

THE COLOUR —It depends upon tho amount of altered bile-pigments mixed with, whereby a bright yellow to a dark brówn colour is obtained

THE COMPOSITION OF FÆCES

1 Products of digestive secretion—as mucin, cholesterin, hydrobilirubin, pigments, cholic acid, stercorine, salts

2 Undigested part of food—as stone, cellulose, &c

3 Products of decomposition of food—as indol, skatol, phenol

INTESTINAL MOVEMENT

PERISTALSIS

Peristaltic movoment is duo to the alternate contraction and dilatation of the two layers of the muscular coat of the gut It is chiefly duo to the circular coat The

contraction and relaxation may begin at any point of the intestine, but work down the intestine in waves so as to propel the contents downwards by narrowing the lumen of the tubes The whole constitutes the worm-like movement Under ordinary conditions they only move when there is a certain bulk of material inside In the small intestine the movement is rapid, while in the large it is sluggish These movements, in health, give rise to no sensation, but they are perceptible when they are quickened by the influence of the irritant The peristaltic movements may be seen and felt when abdominal walls are very thin They are more lively in vegetable feeders

The movements travel from above downwards In abnormal *condition may travel upward direction towards* the stomach It is seen in intestinal obstruction where fæcal matter is vomited

THE CONDITIONS EXCITE THIS MOVEMENT

The intestinal canal contains ganglia in the walls as motor centre The centre is stimulated automatically

1 Want of O and increase of CO_2 increase the movement very much

2 Cold, to the abdomen—either cold air or water increase it

3 Purgative agents increase it, as nux vomica, senna, &c

4 Electricity

DURATION OF INTESTINAL DIGESTION

The ordinary meal takes about 12 hours to travel through *small* intestine, and about 24 hours through the *large* intestine

THE CONDITIONS THAT DIMINISH MOVEMENTS

1 Over-oxygenated state of the blood
2 Heat to the abdomen
3 Drugs, like morphia, belladonna
4 Depressing emotions

EXCRETION OF FÆCES

The intestinal contents become less watery, and assume the characters of fæces in the lower part of the great intestine The fæces are pushed on by the peristaltic movement, until they reach a point a little above that part of the rectum which is surrounded by both sphincters As long as the fæces lie above the rectum, they do not cause any sensation, but the sensation of requiring to go to stool occurs when the fæces pass into the rectum

DÆFECATION

There are two sphincters in the anus in a state of tonic contraction, due to the automatic action of an ano-spinal centre in the lumbar part of the spinal cord When this centre is destroyed by injury or disease of spinal cord, the act of dæfecation becomes involuntary The evacuation of fæces is brought into play when the sensation is felt, the ano-spinal centre is inhibited, and an expelling mechanism brought into play, viz —

1 Deep inspiration to force down the diaphragm

2 Glottis closed, to give it fixed point

3 Muscles of abdominal wall contract

4 The soft parts of the floor of the pelvis are driven downwards, causing mucous membrane of the anus, which contains much venous blood, to be everted

CHAPTER IX.

PHYSIOLOGY OF ABSORPTION AND LYMPHATICS

ABSORPTION

Food is essential for maintaining life It is digested in order to be absorbed, and finally it is assimilated to become integral part of the living material of the body

THE ORGANS OF ABSORPTION —The mucous membrane of the whole intestinal tract, as far as it is covered by a single layer of columnar epithelium, that is from the cardiac end of the stomach to the anus is adapted for absorption The greatest area of absorption is the small intestine owing to presence of the villi And a little absorption goes on in the stomach

THE PATHS OF ABSORPTION IN THE INTESTINES ARE TWO—

1 THE BLOOD CAPILLARIES—absorb peptones, sugar, water and salts The whole substances absorbed pass into the rootlets of the portal vein, and are taken to the liver before they enter into the general circulation

2 THE LACTEALS—absorb chiefly emulsified fats The fat passes into the lymphatics and through thoracic duct chyle is poured into the blood (Thoracic duct opens into the left subeclavian vein)

STOMACH—absorbs water, sugar, peptone, poison The empty stomach absorbs more rapidly than one filled with food

CAUSES OF ABSORPTION

1 DIFFUSION —This is the cause of the absorption of soluble matters Fatty matters are not thus absorbed,

because they are not in solution, but only in a state of suspension

2 FILTRATION—This is the passage of fluids through a membrane, under the influence of pressure, and is the great cause of the absorption of fatty matter It is assisted by—

(1) Peristalsis of the intestine—causing a form of forced pressure

(2) Capillary attraction when the surface is moistened with bile

(3) Contraction of the muscular fibres of the villi, they contract and squeeze out the contents of the lacteals into the underlying lymphatic plexus, and thence to the mesenteric glands and thoracic duct

SUBSTANCES ABSORBED BY THE INTESTINAL WALL

1. ABSORPTION AND DESTINY OF THE PEPTONE

Peptone absorbed by epithelium of stomach and intestine, but is not found either in blood or in chyle When injected into the blood it is excreted by the kidney Peptone is changed into albumen in mucous membrane, probably in the epithelium by which it is absorbed It is supposed that epithelium covering the villi reconverts the peptone into albumen, and give it up to the blood-capillaries lying immediately below the epithelial cells When animals are fed on peptone these serve to maintain the body-weight In cholera epithelium is shed, therefore absorption is diminished

2 ABSORPTION AND THE DESTINY OF THE FAT

As to the absorption of fat, it passes through the body of the epithelial cells The fat enters in small droplets, which in the protoplasm of the cell may run together to form larger ones.

The lacteals in the centre of the villus consists of a delicate layer of endothelium, and communicate with smaller lymph spaces in the adenoid tissue around The fatty particles are carried through these lymph spaces by the lymph stream towards the lacteal Thus they pass into the lacteals

DESTINY —Tho excessivoly fine fatty granules are used up by the tissues, they aro taken up in large amount by the liver, and last of all by the muscles The tissues split up the fats into glycerine and fatty acids, and these are finally oxidised to yield heat chiefly

3 ABSORPTION OF WATER AND THE SOLUBLE SALTS

Water and soluble salts are readily absorbed by the blood and lymph-vessels If salts like magnesium or sodium injected into the intestine may thus cause watery ovacuation

4 ABSORPTION OF SOLUBLE CARBOHYDRATES

Such as sugar It is absorbed in the form of glucose by the capillaries, thence to the rootlets of the portal vein and then into the liver—there glucose is dehydrated and becomes glycogen

NUTRIENT ENEMATA

It is employed in case where food cannot be taken by the mouth In diseases like stricture of the œsofagus, gastric ulcer, continued vomiting, &c, food is given per rectum As the digestive activity of the large intestine is very slight, fluid food ought to be given in order to be absorbed readily Peptonisod food is best, or solution of grape-sugar, peptonized milk, egg with common salt or any commercial peptonised proteids

METHOD —Introduce a tube with a funnel attached into the rectum Let the food to pass in slowly by its own weight The patient must endeavour to retain the enoma as long as possible

LYMPHATIC SYSTEM

Lymphatics occur within the tissues of the body generally They are system of vessels or channels containing juices of the tissues and within these channels the fluid is always moving The fluid is lymph They arise within the tissues, in a variety of ways They unite with each other and form two large trunks, that of the right receives the lymphatics only of the right side of the head and chest, and the right arm, and that on the left side is the thoracic duct Both open into the respective subclavian veins, just where the internal jugular joins them

ORIGIN OF LYMPHATICS

They originate in tissues generally in the following ways —

(1) The lacteals in the villi of the intestine is one mode of origin

(2) Plexiform origin—Begin in irregular networks which communicate with the cell spaces of the connective tissue corpuscles, *e g*, beneath the skin and mucous membrane

(3) Lacunæ origin, *e g*, in the testicle—Begin in shapeless spaces or lacunæ between the several structures of the gland, these spaces may be lined by endothelial cells

STRUCTURE OF LYMPHATIC VESSELS

1 LARGER LYMPHATIC VESSELS —The different coats (inner, middle, external coats) resemble those of veins, only they are thinner and transparent They have valves which open towards the heart

(1) *Inner coat* —Layers of longitudinal elastic fibres lined by oblong endothelial cells with serrated edges

(2) *Middle coat* —Circular non-striped muscular fibres, mixed with circular elastic fibres

(3) *External coat* —White fibrous tissue, and a few longitudinal elastic fibres, also a few longitudinal and oblique non-striped muscular fibres

2 THORACIC DUCT.—It is much the same as the above, except that we have—

(1) A sub-epithelial layer in the inner coat, as in arteries and veins, and

(2) In the middle coat a longitudinal layer of white connective tissue and elastic fibres just internal to the muscular coat

3 Lymph capillaries —These consist of a single layer of endothelial cells with very wavy borders They have no valves In certain parts of the body, *e g*, pleura and other serous membranes have *stomata* for direct communication

LYMPHATIC GLANDS

Lymphatics have glandular enlargement in their course through which the lymph passes to be discharged into the blood-vessels They are small rounded bodies, about the size of a pin-head They are found in the mesentery, and along the great vessels of the abdomen, thorax, and neck, in the axilla and groin They consist of a mass of adenoid tissue Before the lymph passes through the lymph glands it shows but little tendency to coagulate, after having passed through, many white corpuscles are added to it, and it then shows a marked tendency to coagulate

ORIGIN OF LYMPH.

The blood leaves the heart by the arteries, it returns to the heart by the veins, and the thin-walled blood-capillaries transudes part of blood-plasma into the cell spaces of the surrounding tissues This fluid is lymph The tissues are bathed in this fluid, enabling them to receive nourishment and also remove waste products This fluid (lymph) is collected and returned to the blood by the lymphatics

COMPOSITION OF LYMPH

1 It resembles diluted blood-plasma and contains white corpuscles, elements of fibrin, albumen, salts, and water

It contains less proteid matter than blood-plasma This is due to the fact that proteid do not pass readily through animal membrane

2 Effete matters from the tissues as urea, creatin, carbonic acid

CHYLE—is the name given to the contents which occur in the lacteals. The content is found to be milky

MICROSCOPIC CHARACTERS OF CHYLE FROM THORACIC DUCT

1 It shows many oil-globules with albuminous envelopes

2 LYMPH CORPUSCLES—nucleated masses of protoplasm which pass into the blood, where they become *leucocytes*

3 YOUNG RED BLOOD CORPUSCLES —As a rule these are not coloured, but when exposed to the air, they become pale yellow, and the lymph or chyle as a whole becomes pink

DIFFERENCE BETWEEN LYMPH AND CHYLE

LYMPH—is, broadly speaking, blood minus its red corpuscles and slightly diluted

CHYLE—is lymph plus a large quantity of minutely sub-divided fat

DROPSY —This means an excessive accumulation of lymph in connective tissue spaces, and in the greater cavities of the body The transudation of lymph beyond the capacity of the lymphatics to remove it, constitutes dropsy It may be divided into—

1 GENERAL —Where the effusion of fluid takes place more or less throughout the body generally

2 LOCAL —Where particular tissues or organs are affected —

(1) ANASARCA—Dropsy of the integumentary structures

(2) ŒDEMA—Dropsy of the connective tissues and solid organs as leg, arm, face.

(3) ASCITES—Dropsy of the peritoneal cavity

CAUSES OF DROPSY—Causes are numerous It may be due to—

(*a*) Obstructive heart disease.

(*b*) Lung disease.

(*c*) Kidney disease

(*d*) Certain cachectic states

CHARACTERS OF THE AFFECTED PARTS.

Tissues that are œdematous swell up, look pale, are doughy, pit on pressure, and if cut into, a clear watery fluid exudes.

EXCRETORY ORGANS

(INCLUDING KIDNEYS, SKIN.)

THE KIDNEY.

STRUCTURE OF THE KIDNEY—It is a compound tubular gland, and composed of tubes, the *tubuli uriniferi* It has a thin fibrous capsule, but loosely adherent to the kidney, so as to be easily stripped off from the substance of the kidney

NAKED EYE—on dividing the kidney into two halves, it shows two parts, viz —

(1) Outer cortical

(2) Inner medullary, or pyramidal

The upper part of the ureter is dilated into the *pelvis*, and this again is subdivided into *calicis* Each of these calicis receives the papilla of a pyramid

The medullary portion consists of about twelve pyramids These pyramids are separated by cortical substance The cortex has a light brown colour, and when torn presents a slightly granular aspect, with radiating lines running at regular distance The granules are due to the presence of the malpighian corpuscles, and the striæ to the medullary rays The medullary portion is further subdivided

(1) THE BOUNDARY LAYER with its wall-marked striations due to the vasa-recta, and bundles of straight tubes

(2) The *papillary layer* this is of a uniform dull red colour

THE URINIFEROUS TUBULES —They begin in the cortex in an expansion called Bowman's capsule After pursuing a complicated course, altering their direction, diameter, and structure, and being joined by other tubules, they ultimately form large collecting tubes which terminate through the papillæ into the pelvis of the kidney, and thus discharge the urine

THE COURSE AND STRUCTURE OF ONE OF THE TUBULI URINIFERI.

1 TUBULI URINIFERI —The tubules arise as *Bowman's capsule*, into this is pushed a tuft of blood-vessels, invaginating on one side of the capsule This tuft is called the GLOMERULUS or MALPIGHIAN CORPUSCLE These are only found in the cortical portion of the kidney In structure the *capsules* consist of a basement membrane and a single layer of squamous epithelium.

The tubule leaves the capsule by—

2 The NECK of tubule —(Structure as above) and then becomes

3. PROXIMAL CONVOLUTED tubule—ends at inner border of cortex

STRUCTURE—lined with short columnar cells, sometimes irregular in shape, and the cells show a fibrillated structure

4 SPIRAL TUBULE passes down in a spiral manner, and is of the same size and structure as the last. This rapidly narrowing leads to—

5 DESCENDING LIMB OF HENLE'S loop in the boundary layer of the Malpighian pyramid, then

6 The loop itself in the papillary layer, and then (STRUCTURE —The cells are clear and flattened and lumen is large)

7 The thick part of the ASCENDING LIMB OF HENLE'S loop this part is wider than the other parts of the looped tubule of Henle

STRUCTURE —The cells are striated and fill the tubule

8 About midway in the boundary layer the ascending limb narrows again, forming the ASCENDING SPIRAL OF HENLE'S LOOP The tube now re-enters the cortex and forms

9 The narrow ascending limb in the medullary rays

10 IRREGULAR TUBULE, which has a very irregular and angular outline, and is lined with angular and imbricated cells, with exceedingly well-marked striæ

11 The tube next becomes convoluted, forming the DISTAL CONVOLUTED TUBE

STRUCTURE —Resembles the proximal convoluted tube.

12 CURVED COLLECTING TUBULE, opening at right angles into the

13 STRAIGHT COLLECTING TUBULE —In both cases lined with cubical or columnar epithelium It passes down through the Malpighian pyramid, joins with others to form larger tubes, and finally opens at the apex of the papilla as the

14 15 DUCTUS PAPILLARES —The collecting tubes are lined with transparent nucleated columnar cells.

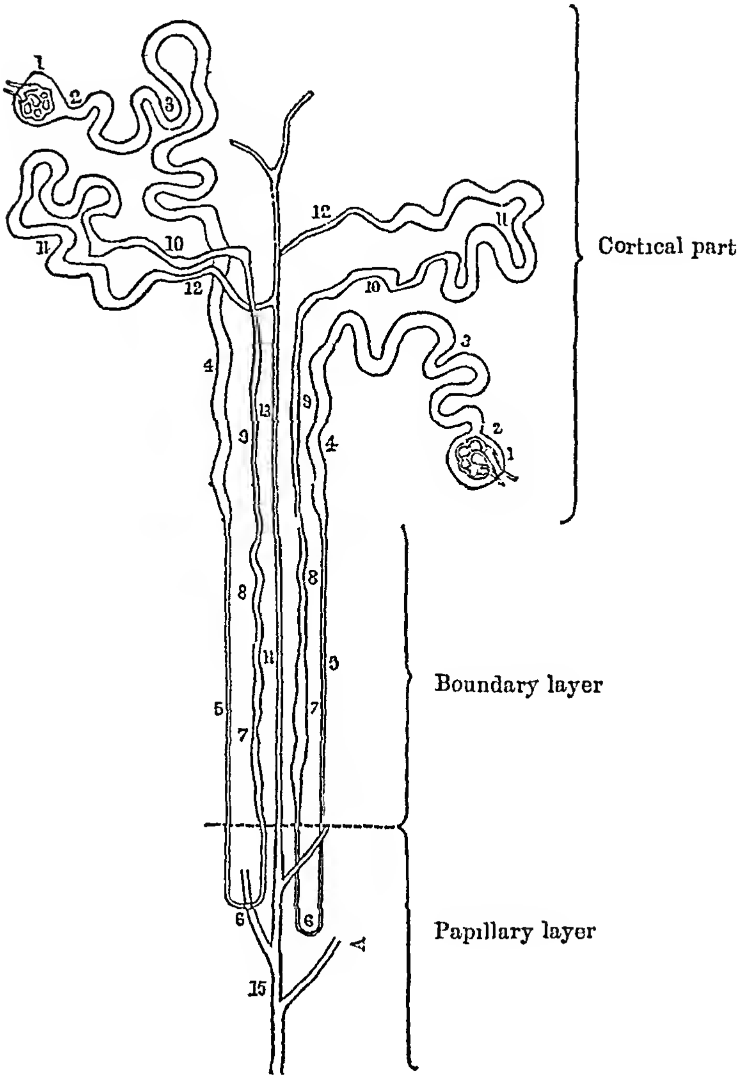


Fig 19 The Uriniferous Tubules

THE SECRETORY PARTS OF TUBULE ARE—

(1) The glomeruli.
(2) Proximal convoluted tube.

(3) Broad part of Henle's loop

(4) Distal convoluted tube

BLOOD VESSELS OF THE KIDNEY.

ARTERIES OF THE KIDNEY—The RENAL ARTERY divide into branches on entering the hilum of the kidney These branches pass towards the cortex. They reach the bases of the pyramids on the limits between the cortical and boundary zones where they form *incomplete arches.* From these arches branches are given off—

1 INTERLOBULAR ARTERIES

They run vertically and singly into the cortex and in their course they give off—

(1) AFFERENT VESSELS—each of which enters a Malpighian capsule from which the urinary tubule is given off Within the capsule each afferent vessels break up into capillaries, forming a tuft of capillary blood-vessels called *Malpighian tuft* or glomerulus from which smaller vessel

(2) EFFERENT VESSELS arise which breaking up into capillaries ramify over and between the convoluted tubules of the cortex These unite to form veins

2. CAPILLARIES OF MEDULLA —Branches come from the arches running downwards into the pyramids, passing between the bundles of collecting tubes, called the vasa recta or arterial rectæ.

VEINS OF THE KIDNEY

The branches of renal vein form similar arches They receive blood from

1 The *interlobular veins* correspond with the arteries, and into these the stellate veins beneath the capsule open.

2 The *venæ rectæ* run along the pyramids with the corresponding arteries.

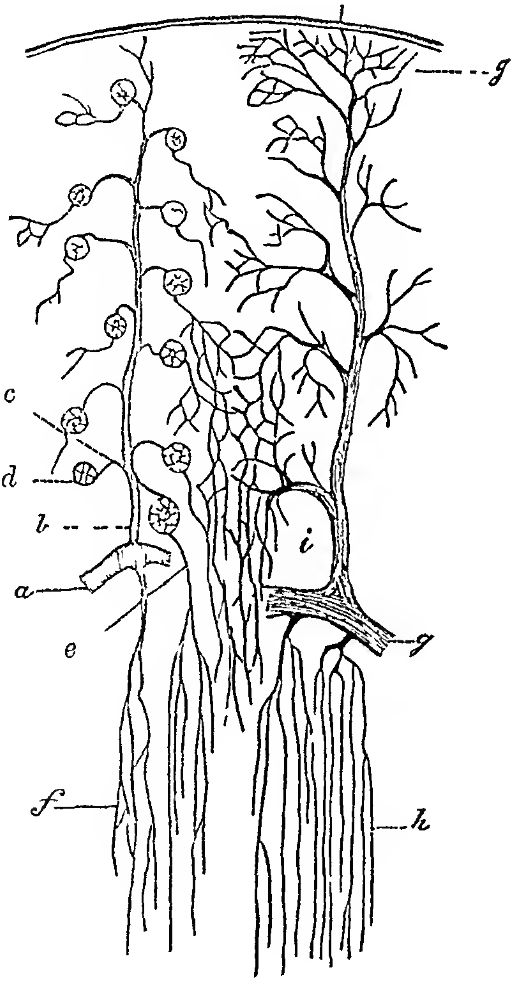


Fig 20 Vascular supply of Kidney

a, part of arterial arch, *b*, interlobular artery, *c*, afferent vessel, *d*, glomerulus, *e*, efferent vessel, *f*, capillaries of medulla, *g*, venous arch, *h*, venæ rectæ, *j*, vena stellata, *i*, interlobular vein

THE URINE.

A thorough knowledge of PHYSICAL and CHEMICAL characters of the urine is of the utmost importance for Physician and Surgeon

I PHYSICAL CHARACTER

1. The QUANTITY of urine passed in twenty-four hours is 45 to 52 ounces

VARIATION IN THE QUANTITY.

(*a*) THE AMOUNT IS DIMINISHED—

(1) In hot summer by profuse sweating.
(2) Diarrhœa
(3) Thirst
(4) Non-nitrogenous food.
(5) After severe hæmorrhage
(6) In some disease of the kidneys

(*b*) THE AMOUNT IS INCREASED—

(1) By copious drinking
(2) In winter by contraction of the cutaneous vessels through the action of cold
(3) In diabetes mellitus and diabetes insipidus.
(4) By certain drugs as digitalis, alcohol, &c
(5) By the influence of nervous system as hysteria

2. THE COLOUR—pale straw to dark amber according to degree of concentration of the solution of normal urobilin derived from the bilirubin of the bile (colouring-matter of urine) and also amount of water used

VARIATION IN THE COLOUR OF THE URINE—

Changes in colour may be caused by alteration in the relative proportions of the colouring matters and the water of the urine, or by the presence of abnormal substances This will be detailed further on

3 THE TASTE is saline bitter, the odour is aromatic Temperature is about 39° C.

VARIATION IN ODOUR

(1) When the alkaline fermentation begins, there is an ammoniacal smell

(2) The urine frequently assumes the smell of substances which have been taken internally as onions, turpentine, copaiba, cubebs, and many other aromatic drugs

4. REACTION OF URINE.

It is usually acid, due to the presence of acid sodium phosphate, after a diet of flesh, acid potassic phosphate is the cause of the acidity There is no free acid in the urine.

VARIATION IN REACTION

The reaction varies, however, at different periods of the day Urine is strongly acid in the morning after muscular exertion, after the use of acids, *e g*, hydrochloric acid, &c, and in summer.

The reaction of urine is much affected by diet, it is less acid during digestion or it becomes alkaline after full vegetable diet It becomes alkaline after the use of alkalies, magnesia, &c Alkaline urine is found in many pathological conditions

ALKALINE FERMENTATION OF THE URINE

Occurs if urine kept long in hot weather The urine gives ammoniacal odour due to decomposition of urea by the action of micrococcus urea which causes the urea to take up water, and decompose into CO_2 and ammonia thus—

$$\underset{\text{urea}}{(CO\,N_2H_4} + H_2\,O = \underset{\text{ammonium carbonate}}{(NH_4)_2\,CO_3}$$

It gives alkaline reaction having deposit of earthy phosphate (ammonia-magnesium-phosphate) or triple phosphate The same happens inside of the bladder in diseased condition of the organ

5 THE SPECIFIC GRAVITY OF THE URINE

The specific gravity depends upon the relative amount of the fluid and solids of the urine, in health it usually

varies between 1015 and 1025, the normal specific gravity of the healthy urine of twenty-four hours being 1020.

THE SPECIFIC GRAVITY IS ESTIMATED by means of a urinometer, the urine being at the temperature 16° C. Before taking the specific gravity of the urine, it should be tested in distilled water at first When urinometer is placed in distilled water, it ought to float at the mark 0° or zero, which is registered 1,000. Place the urine in tall glass vessel and leave urinometer in it slowly It will float and not touch the side of the vessel. Take care that no air-bubbles adhere to the instrument When reading off the mark on the stem, raise the vessel and note the number of stem corresponding to the level of water It is essential that sample of mixed urine of twenty-four hours should be used for ascertaining specific gravity.

The daily amount of solids excreted by the kidney is estimated by means of specific gravity.

CHRISTISON'S FORMULA

Take sp gr of mixed urine of 24 hours, and multiply last two figures of sp. gr. by 2 33 = solids in 1,000 parts of urine, further work out that how much solids would be in certain known quantity of urine This is only applicable to ordinary urine

VARIATION IN SPECIFIC GRAVITY OF URINE is pathological It will be described in the examination of urine—

II CHEMICAL CHARACTER OF THE URINE

THE CONSTITUENTS OF THE URINE ARE—

1 It consists of 95 per cent of water The daily amount is 45 to 52 ounces, but this varies—

(a) With the amount of water taken

(b) The amount of excretion by the skin

2. The next constituent is 5 per cent. solids. The daily amount excreted is about 2½ ounces or 60 to 70 grammes, but this varies—

(*a*) With the kind of food eaten, *e g*, proteid food increases

(*b*) With variation in tissue metabolism

The following table gives approximately the average quantities of the chief substances excreted in the urine by a healthy adult in twenty-four hours —

			Excreted daily			
1	Water	...	95	per cent	452	ounces
2	Solids		5	„	2½	„
3	Organic	Urea	2 2	„	500	grains
		Uric acid	0 05	„	10	„
		Hippuric acid	0 01	„	15	„
		Creatin .	0 07	„	15	„
4	Inorganic	Phosphate ...	1 0	„	40 80	„
		Chloride of Na, K	0 8	„	250	„
		Sulphate of K	0 7	„	30	„
5	Pigments and mucous		0 03	„		
6	Extractives of urine	...	Traces			

Sugar

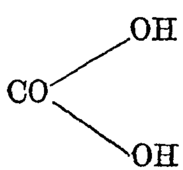
Xanthin

Oxalic acid

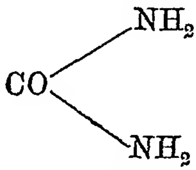
Lactic acid —*Rutherford*

GENERAL CHARACTERS OF UREA ($CO\ N_2H_4$).

It is the chief end-product of the oxidation of the nitrogenous constituents of the body In its composition it is related both to carbonic acid and ammonia. It is regarded as the diomide of carbonic acid, thus carbonic acid may be written in the hydrated form—



Replace the hydroxyl groups by ammidogen (NH_2) and we have urea—



It crystallises in silky four-sided prisms It has bitter, cooling taste, is readily soluble in water and alcohol. Urea is further isomeric with ammonium cyanate, and by evaporating it, urea may be prepared

When treated with nitric acid, nitrate of urea is formed, this crystallises in lozenge-shaped tablets

DAILY EXCRETION OF UREA.

An adult person 500 grains excretes urea in twenty-four hours, in normal urine it forms rather more than one-half the total solids It is the greatest ozotised derivative of proteids and their allies, the amount is much affected by diet; the following lists of food will show the quantity influenced by diet —

Mixed diet	.	500 grains daily.	
Animal diet	.	821	„
Vegetable diet		347	„
Non-ozotised diet	.	237	„

The quantity is increased in diabetes millitus, fever, inflammatory affections, after use of excess of water and common salt

SITES FOR UREA

Urea occurs in the blood, lymph, chyle, liver, lymphatic glands, spleen, lungs, liver, brain, eye, bile, saliva.

ANTECEDENTS OF UREA

During digestion, part of the proteid is converted into leucin, tyrosin, glycin, and aspartic acid If the amido-acids, glycin, leucin, or aspartic acid, or ammoniacal salts be

given to an animal, the amount of urea excreted is increased. As the molecule of the amido-acids contains only one atom of N, and the molecule of urea contains two of N, it is probable that urea may be formed synthetically from these acids

SOURCES OF UREA.

1 Tissue metabolism

2 Proteid matters of the food

FORMATION OF UREA

Urea is not formed in the kidneys It is secreted or separated by the kidneys from the blood passing through them In diseased condition of kidney, urea is still formed, but it is absorbed giving rise to condition called *Uræmia*

The urea is derived from proteids, and the liver is the organ in which it is formed It is then carried by the blood to the kidney, and is there excreted It is shown by the fact, if the liver be washed free from the blood, more urea will be found in hepatic cells than in any other tissue Also, in acute yellow atrophy of the liver, the urea is greatly diminished in the urine, but instead of it, we find abundant deposits of leucin and tyrosin, and these substances are its antecedents Further pointed out that in hepatic abscess, during the early congestive stage, the urea in the urine is increased, while it is diminished in the suppurative stage, when hepatic tissue is destroyed.

EXPERIMENT —Kill a dog and remove its blood and defibrinate it Excise the liver and make the defibrinated blood mixed with ammonium carbonate to circulate through the liver It becomes urea. Try the same experiment with kidney, no result

GENERAL CHARACTER OF URIC ACID ($C_5H_4N_4O_3$).

Uric acid is the nitrogenous substance which removes

most of N from the body. About 10 grains daily is excreted by adult in twenty-four hours

PROPERTIES —It is dibasic, colourless, and when examined microscopically is found in rhombic crystals of many different forms Usually they are lozenge and oval shaped plates and rods, most common forms of crystal. Crystals of uric acid are usually yellowish in colour from the pigment of the urine

OCCURRENCE —Uric acid does not occur free in the urine. It is usually combined with soda and potash as acid sodium urate and acid potassium urate They are very soluble in hot water, and as the urine cools, they are thrown down as the *"brick-dust"* deposit, especially if the urine be concentrated by evaporation from the skin (sweat), as after a brisk walk.

FORMATION OF URIC ACID

It is not known experimentally in man It is not formed in the kidney, occurs in the blood In gout, when there is a diminished excretion of uric acid, it accumulates in the blood and tissue It is supposed that it is formed in the liver and in the kidney becomes *urates*, ammonia and lactic acid are probably synthesised to form uric acid.

VARIATION IN EXCRETION OF URIC ACID.

It is increased in—

1. Ague or all febrile condition
2. Gout, after the attack is over
3. Enlarged spleen.
4. Flesh diet
5. Sedentary habits
6. Imperfect oxidation in the body as confined in the room

It is diminished by—

1. Excess of water

2. Vegetable diet
3 Potassium iodide
4 Muscular exercise
5 During attack of gout

GENERAL PROPERTIES OF CREATIN AND CREATININ

Fifteen grains daily of each are excreted.

CREATIN is increased by flesh diet, but it also comes from tissue metabolism It is found in muscle, nerve and blood It becomes transformed into creatinin and excreted by the kidney

CREATININ is creatin minus H_2O and may be got by boiling creatin.

It is increased by proteid diet, and is diminished when food is wanting.

GENERAL PROPERTIES OF HIPPURIC ACID.

It is much found in herbivora, especially the horse (hence its name). In human urine the amount is small, but vegetable diet increases it It is supposed to be derived from a substance resembling benzoic acid in the cuticular parts of plants. Give benzoic acid, it is much increased, benzoic acid unites with glycocin to form hippuric acid.

FORMATION OF HIPPURIC ACID

It is formed in the kidney by the union of benzoic acid, present in the cuticular coverings of the food with glycocin of blood It is shown by the fact —If arterialised blood containing benzoic acid and glycocin be passed through the blood-vessels of a fresh, living excised kidney, hippuric acid is found in the blood The vitality of the kidney gives union of the two substances to form hippuric acid Even benzoic acid alone is given by the mouth, hippuric acid appears in the urine. The hippuric acid in the urine renders alkaline urine acid, and it stimulates and disinfects the urinary mucous membrane.

COLOURING MATTERS OF THE URINE

NORMAL UROBILIN is the chief pigment of the urine. It gives a red or reddish-yellow colour to urine, which becomes yellow on the addition of ammonia It is most abundant in the highly-coloured urine of fever The pigment was named urobilin, on the idea it is modified bile-pigment absorbed from the intestinal canal into blood, and excreted by the kidney It is derivative of hæmatin, which also yields the bile-pigment

INDICAN or indigo-forming substance is a normal constituent of human urine, but present in small amount. It is bile-pigment It is derived from indol, one of the products of the putrefactive decomposition of proteids in the intestine It is increased in urine when there is undue retention of intestinal contents

UROERYTHRIN is a pigment which carried down when urates are deposited, and gives to them their brick-red tint

ORIGIN OF THE MUCUS IN THE URINE.

It is secreted by the urinary passages, and not by the kidney

THE INORGANIC CONSTITUENT OF THE URINE.

Chloride of sodium and chloride of potassium These come from the corresponding salts of the food, and but slightly from tissue metabolism

It is diminished in diseases Pneumonia, inflammation with effusion, continued diarrhœa, dropsies In pneumonia chloride may at a certain stage disappear from the urine, and it is a good sign when chloride begin to reappear

PHOSPHATES (Ortho-phosphates) occur in the urine They are more abundant after an animal than after a vegetable diet They are derived partly from the food and partly from tissue metabolism, especially nerve tissue, *e g*, from lecithin and nuclein. As phosphorus is an important

constituent of the nervous system, phosphates are increased in over activity of nervous tissue and also in nervous diseases

SULPHATES —Chiefly derived from decomposition of proteids

THE SECRETION OF URINE

THE FUNCTIONS OF THE KIDNEY ARE—

(1) To separate waste products from the blood, chiefly nitrogenous bodies and salts

(2) To excrete water

THE PARTS OF THE KIDNEY ARE CONCERNED IN SECRETION OF URINE—

(1) The glomeruli—for water

(2) Epithelium of the convoluted tubes proximal and distal—for solids

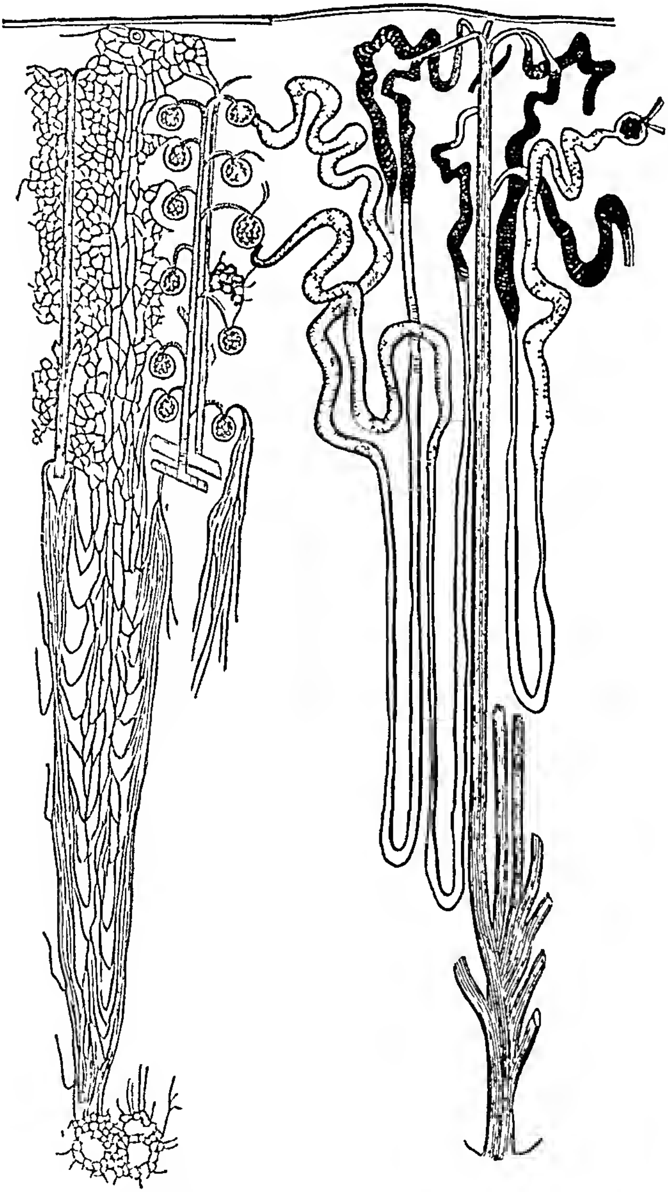
MECHANISM OF SECRETION OF URINE—BOWMAN'S THEORY

The secretion of urine is double process, partly *mechanical* and partly *vital*

1 THE MECHANICAL part is the filtration of fluid through the capillaries of the glomeruli In other words, the watery part of the urine is filtered through glomeruli The reason for supposing that the excretion of water is mainly a process of filtration is a simple one, that flow of urine seems to obey the same laws of pressure as the flow of water through a filter For example, whatever increases the blood pressure in the renal arteries tends to increase the flow of urine If the heart beats more quickly than usual, more urine is excreted

2 THE VITAL part is the excretion of the solids by the vital activity of the epithelial cells lining the above-mentioned tubules In other words the solids are secreted by the epithelium of the tubules and removed from the

epithelium by the water flowing along the tubules The preceding diagram shows the mechanism of secretion of urine



Blood capillaries with glomeruli — Urinoferi tubuli

Fig 21 Diagram showing the mechanism of secretion of urine

ACTION OF THE GLOMERULI

The watery part of the urine is filtered through the capillaries of the glomeruli into the Bowman's capsule which is the commencement of each renal tubule The amount of water which is filtered depends upon the blood-pressure in the area of the renal artery

THE SECRETION DEPENDS UPON THE BLOOD-PRESSURE—The higher the pressure, the more urine filters through The pressure in the glomeruli is naturally higher than that in the capillaries in the other parts of the body Because the glomeruli are supplied with afferent vessels, and the efferent vessels which have a smaller calibre, and thus there is higher pressure The pressure varies according to the contraction or relaxation of the renal arteries, if relaxed, there is a local increase of pressure and therefore more urine filters through, when constricted the opposite occurs

SOME OF THE PROOFS THAT SECRETION DEPENDS UPON THE BLOOD-PRESSURE

1 INCREASED ACTION OF THE HEART—When the tension and rapidity of the blood in the arteries are increased, there is an increase in amount of urine Conversely feeble action of the heart diminish the amount of urine

2 LESIONS IN THE MEDULLA—Puncture the floor of the fourth ventricle, there is increased filtration of urine

3 GENERAL VASO-MOTOR PARALYSIS—In this case—from section of the spinal cord below the medulla—the filtration of urine stops, because the blood-pressure in the glomeruli is lowered too much! This being the case, there is a general fall of pressure, instead of a local increase Cut the renal nerves first, there is increased filtration of urine, then cut the spinal cord in the neck, the secretion almost stops Stimulate the lower end of the divided cord, there is a great secretion of urine, because there is a great increase in the blood-pressure both generally and locally. In this latter case, if the renal nerves are intact,

there would be little or no urine, because the renal arteries would be too much constricted for the blood to get through

4 INJECTION OF WATER INTO THE BLOOD — Even though there is no change in the blood pressure, yet there is an increased flow of watery urine

5 STATE OF THE SKIN AFFECTS SECRETION — Cold to the skin increases the amount of urine It is produced by contraction of the cutaneous vessels causing the pressure of internal organs raised Heat to the skin diminishes the secretion of urine, because the cutaneous vessels are dilated, and so the pressure in the internal organs is lowered, and therefore there is less filtration through the glomeruli The loss of water owing to profuse sweating or diarrhœa, copious hæmorrhage, or prolonged thirst, diminish the secretion of urine

6 Drinking large quantities of water increase the amount of urine, because the blood becomes more watery

7 EMOTIONS AFFECT THE SECRETION —In many emotional states, such as hysteria, fear, etc , cause increase of secretion, probably due to flushing of the blood-vessels of the kidney by direct action on the renal nerves, to contraction of the peripheral capillaries, there is no increase in the solids

8 Most diuretics act either directly upon the renal cells, or through the influence of the nerves increasing blood pressure

SECRETION OF SOLIDS BY THE RENAL EPITHELIUM

The secretory cells of the epithelium of the tubules take up the substances from the blood and secrete by their own vital activity The water as it flows from the glomeruli along the tubules washes out the substances secreted from the epithelium

HEIDENHAIN'S EXPERIMENT IN REGARD TO THE ACTION OF THE RENAL EPITHELIUM

He showed that most of the solids of the urine are excreted by the epithelium of the proximal and distal convoluted tubules.

Experiment 1.—Inject indigo-carmine into the jugular vein of a rabbit, and kill the animal and harden the kidneys in alcohol, and examine. The convoluted tubules are blue, but not the glomeruli, as the indigo got excreted by the vital activity of the epithelium of the tubules. A little after the injection, so as both tubules and glomeruli have secreted, examine the kidney, blue is found in the lumen of the urinary tubules, being washed out by the watery part of the urine.

Experiment 2.—This is to be done when the tubules are secreting, and the glomeruli are not. This may be brought about—Cut the spinal cord in the neck, this stops all filtration. Inject indigo-carmine as above, and examine the kidney, the medullary is colourless, but the cortical part is deeply-stained blue, and no blue pigment is found in the glomeruli. The blue has been secreted by the epithelium of convoluted tubes, but has not been washed down. Owing to the arrest of the watery part of the secretion, the blue remains in the cortex.

Experiment 3.—Apply caustic (silver nitrate) at two places. Caustic stops secretion from the glomeruli. Inject indigo and examine as above. Kidney is blue throughout, except at the point where caustic is applied.

EFFECT OF EXCISING ONE OR BOTH KIDNEYS.

Excise one, no harm results, provided the other one be sound. Excise both, and death follows very speedily, and the same result follows if both ureters are tied—coma, convulsions, and death from uræmia.

THE FLOW OF URINE.

KIDNEY.—The urine is excreted continuously in the kidneys. The two kidneys never secrete symmetrically, they exhibit an alteration of secretory activity. The urine is continuously poured by two ureters into a reservoir, bladder. From this reservoir the urine is intermittently ejected by the urethra.

STRUCTURE OF PELVIS OF KIDNEY AND URETER

PELVIS OF KIDNEY —At the hilus the ureter dilates into the pelvis, this divides into two or three primary divisions, and these end in a larger number of calices, into which the apices of the Malpighian pyramids are pushed The pelvis is lined by a mucous membrane consisting of connective tissue and covered with several layers of stratified transitional epithelium

THE URETER has three coats—

(1) External or fibrous

(2) Muscular, two layers—

(*a*) Inner-longitudinal layer of non-striped muscular fibres

(*b*) Outer-circular layer The muscular layer ceases at the apex of the pyramids, where they are disposed circularly, to form a kind of sphincter muscle for each papilla Possibly these sphincters contract to squeeze out the urine into the pelvis

(3) MUCOUS COAT consists of stratified transitional epithelium

THE PASSAGE OF URINE TO THE BLADDER —The urine is forced down the ureter, as the secretion of the urine goes on continually under a high pressure in the kidney, and the pressure in the ureters is low, so urine is propelled The muscles of the ureters contract rhythmically and peristaltically, and propel it towards the bladder This movement is reflex Every three-quarters of a minute several drops of urine pass into the bladder The ureters perforate the wall of the bladder very obliquely, and this acts as a valve and prevents reflux

LOCAL STIMULATION —In case of suppression of urine, application of heat to the kidney and down to the ureter excites the secretion and propulsion of the urine

STRUCTURE OF BLADDER AND URETHRA

BLADDER has three coats—

1 SEROUS COAT—has same structure as peritoneum

2 MUSCULAR COAT —Three layers of non-striped muscular fibres.

(1) Internal—circular.
(2) Middle—oblique
(3) External—longitudinal (detrusor muscle)

Function—By the contraction of the muscular fibres the size of the bladder is diminished uniformly, and thus urine is expelled

3 MUCOUS COAT—Loosely connected and often wrinkled, except at the trigon, where it adheres directly to the muscular coat It is lined by stratified transitional epithelium. There are mucous glands in the mucous membrane, near the neck of the bladder, the function of which to secrete mucus of the urine

SPHINCTERS OF THE BLADDER—There are two sphincters

(1) INTERNAL SPHINCTER consists of non-striped muscle It surrounds the orifice of the urethra as far down as the prostatic portion

(2) EXTERNAL SPHINCTER lies below the latter It is circular muscle disposed around the urethra, close above the entrance of the urethra

Function—The urine is retained in the bladder by the tonic contraction of the sphincter, due to the automatic activity of the centre in the lumbar part of the spinal cord

STRUCTURE OF URETHRA

IN THE FEMALE, the urethra serves merely for the passage of the urine The mucous membrane is lined by stratified epithelium and contains mucous glands

IN THE MALE, the urethra has the same epithelium as in the bladder The mucous membrane is beset with papillæ and contains the mucous glands

MECHANISM OF THE ACT OF MICTURITION

After emptying the bladder, the urine slowly accumulates, the bladder gradually becomes distended, and a desire is felt to make water Micturition itself is a reflex act, but it is more or less under the control of the will. There

are probably *two centres* concerned in the lumbar part of the cord

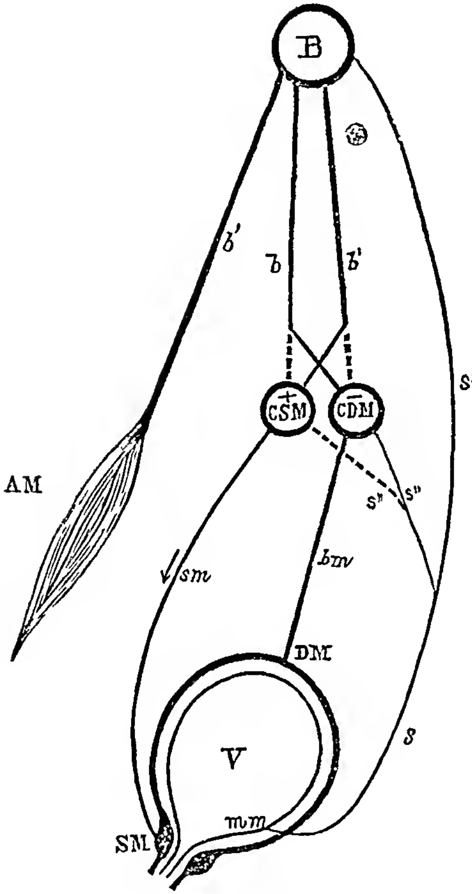


Fig 22

Diagrammatic representation of the parts concerned in the mechanism of micturition while at rest (After *Gowers*, but considerably modified by Bramwell)—The sphincter muscle (SM) is in a state of contraction, the result of nerve force continually sent to it from its tonic centre (C S M) in the spinal cord, through *sm*, as indicated by the arrow V=the bladder which is represented as empty S M, Sphincter muscle D M, Detrusor muscle, A M, Abdominal muscles *mm*, Mucous membrane of bladder B, The brain C D M, Spinal centre for the detrusor muscle C S M, Spinal centre for the sphincter muscle S, S′, S″, S‴, Sensory fibres proceeding from the mucous membrane of bladder up to the spinal cord and brain *dm*, Motor nerve, from the spinal centre for the detrusor muscle *sm*, Motor nerve from the spinal centre for the sphincter muscle *b*, Nerve filament proceeding from the brain to the spinal centres of the detrusor and sphincter muscles An impulse from the brain through *b* inhibits the sphincter centre (dotted line) and excites the detrusor centre *b″*, Nerve filament proceeding

1 FOR THE SPHINCTER—automatic

2 CENTRE—which when stimulated, excites contraction of ditrusor muscle When the bladder becomes distended, there is an efferent impulse sent from the mucous membrane of the bladder, to the posterior part of the brain. As the result of this sensation of a voluntary impulse is emitted from the brain, which is twofold (*vide* diagram)

(1) Voluntary inhibition of the sphincter centre, and

(2) Stimulation of the centre for detrusor muscle

The micturition is assisted by the contraction of the muscles of the abdominal wall, which thus press upon the full bladder, and the water is forced through the urethra, —its passage being assisted by the contraction of the accelerator urinæ

If the spinal cord be cut or diseased, micturition may become purely reflex, being managed entirely by the centre in the lumbar region of the cord without any help from the brain Sometimes the sphincter centre is paralysed, and the urine trickles away

RETENTION OF URINE —When the urine is retained in the bladder by any cause for a considerable time, the urine is apt to undergo ammoniacal decomposition, and urea and water are decreased, giving rise to uræmia

CLINICAL EXAMINATION OF URINE

The examination of urine depends upon quantity, specific gravity, odour, reaction, colour, chemical examination, deposit, microscopic examination

1. QUANTITY —In order to have a true estimate of the state of the urinary secretion, it is necessary to examine specimen taken from the total quantity passed during a period of twenty-four hours

Normal quantity, 45 to 52 ounces (1300 C C to 1500 C C). Changes in quantity may be physiological or pathological.

(*a*) PHYSIOLOGICAL —

Increase due to fluid introduced into the system or cold

Decrease due to loss of water by skin (perspiration) and bowel

(b) PATHOLOGICAL —Changes in the structure of the kidney give rise to alteration in the amount of its secretion.

INCREASED—in waxy kidney, cirrhosis of the kidney In diabetes mellitus and insipidus, hysteria, fright

DIMINISHED—in acute inflammation of the kidney, cardiac disease, fever

SUPPRESSED—in obstruction in the urinary channels, such as stone in the pelvis, or organic disease of the kidney In acute febrile disorder, shock, collapse

2 SPECIFIC GRAVITY—Normal, 1015 to 1025 If above 1025, test for sugar

The specific gravity depends on the relative amount of solids. Increased specific gravity and diminished quantity indicate fever, renal disease, presence of albumen

Diminished specific gravity indicates cirrhosis of the kidney

3 ODOUR—The normal odour is peculiar and characteristic It becomes ammoniacal and putrid due to the decomposition of urine when it is kept long in dirty vessel in hot weather It frequently assumes the smell of substances taken internally, such as onion, copæba, and smells like sweet violets after the administration of turpentine It smells like honey when sugar is present.

4 REACTION—is normally acid, variation may be due to physiological or pathological

PHYSIOLOGICAL —The reaction is alkaline after a meal containing much vegetable food, and also after use of alkalies Decomposed urine is alkaline (mentioned already).

PATHOLOGICAL —Urine is alkaline in reaction in diseases of kidney and bladder

TEST.

ACID—a drop of urine turns *blue litmus* paper red

ALKALINE—a drop of urine turns *red litmus* paper blue May be tested also on turmeric paper

5 COLOUR —Normal, pale straw to dark amber. The changes in colour of urine may be due to physiological or pathological

PHYSIOLOGICAL —The changes may be due to alteration in the relative proportions of the colouring matters and the water of the urine As in winter urine is pale, due to increase in quantity. On the contrary in hot weather urine is deep in colour, due to diminution in quantity The morning urine is always more highly coloured than that passed during the day. After use of certain drugs urine is changed in colour, *e g*, salol, carbolic acid make the urine dark in colour Intra-venous injection of blood makes the urine port wine colour

PATHOLOGICAL —Change in colour due to the presence of abnormal substances

(*a*) In simple polyurea, in diabetes insipidus, in diabetes mellitus, in renal cirrhosis and waxy kidney, urine is *pale* in colour

(*b*) In febrile condition, and in the scanty urine of certain renal and circulatory disease urine is *deep* in colour

(*c*) If urine is red, or smoky or reddish brown, suspect presence of blood which may have its origin in various urinary channels, and may accordingly present different appearance

(1) BLOOD arising from the walls of the *urethra* is *not mixed* with the urine, but appears as a small clot at the beginning of the act of micturition

(2) BLOOD arising from the bladder, the first of the urine is passed usually unaltered in appearance, but that discharged towards the end of micturition is *deeply coloured*, and contains clots of various shapes

(3) BLOOD arising from the kidneys, the blood is diffused throughout the urine and blood clots are rare The blood is intimately mixed with the urine

In HÆMATURIA the colour varies greatly, and the urine is never clear When blood is only present in small quantity, the urine is *smoky* in appearance Albumen and epithelium in the urine may often be found Under microscopic examination, blood corpuscles are also revealed On standing the urine deposits reddish-brown sediment, in endemic hæmaturia the ova of the Bilharzia hæmatobia are found In Hæmoglobinuria urine is *reddish-brown* in colour If urine be stood for sometime in a urine glass, it separates into two well-marked layers , the upper layer is port-wine tint, and the lower brownish-grey colour of having deposit of sediments at the bottom The sediments under the microscopic examination reveals broken down corpuscles, hyaline and hæmoglobin tube costs. Such urine turns solid on boiling due to albumen

It must not be forgotten that the urine may contain blood which has flowed from the vagina, and the fact must not be overlooked that blood may be added to urine in order to deceive the medical attendant

6 IF GREENISH BLACK or yellowish brown, suspect presence of bile If such urine is violently shaken, the froth formed on the surface assumes a bright yellowish or greenish colour

7. MILKY APPEARANCE of urine due to presence of fatty-matters is found in condition known as *chyluria*

8 A VERY DARK, even black colour of urine due to presence of melanin is found in case of chronic ague and melonotic cancer

9 INTERNAL USE OF CERTAIN drugs, such as senna, rhubarb, santonin and picric acid give yellow tint to acid urine Quinine renders the urine dark

10 CARBOLIC ACID POISONING —The urine is of a dark green colour, changing to black on exposure to air

11 If urine dirty whitish, containing ropy mucus 'and pus which form on standing a distinct layer at the bottom of the vessel, indicates inflammation of bladder or prostate Such urine is alkaline and offensive and contains triple phosphate in the deposit Pus in the urine may be brought out by the different urinary channels

(*a*) PUS FROM urethra always comes out in first act of micturition.

(*b*) PUS FROM bladder and prostate always associate with urine during and after act of micturition

(*c*) Pus from the pelvis of the kidney, its appearance in urine is always intermittent.

12 FEBRILE UROBILIN —In fevers the colour of the urine is very dark due to increase of urobilin

CHEMICAL EXAMINATION

1 NORMAL CONSTITUENT.

UREA —The presence of urea can always be demonstrated by evaporating the urine to about half its bulk, adding nitric acid On cooling the mixture, shining rhombic crystals of nitrate of urea are seen throughout the fluid Volumetric analysis of urea may be performed by means of solution of *hypobromite of sodium*, which decomposes urea into *carbon dioxide*, *nitrogen*, and *water*. Hufner's hypobromite process is commonly employed For details read any text-book A very simple and exceedingly cheap modification of this process has lately been introduced by Doremus and Thursfield

THE APPARATUS REQUIRED

It consists of a graduated tube and a pipette The tube is closed at the upper end, curved at the lower end, and terminates in a bulk The upper part is graduated, each division indicating 0 001 gramme of urea in 1 cubic centimetre of urine, and a mark at the end shows how much of the reagent is required The pipette has a mark indicating 1 cubic centimetre, and an india-rubber bulb for suction

METHOD

In order to use the apparatus, pour the solution of sodium hypobromite up to the mark, filling the graduated arm, and add sufficient water to fill the bend and lower part of the bulk.

Draw the urine into the pipette as far as the mark on it Pass the pipette into the tube as far as the bend, and squeeze the india-rubber bulk so as to eject the urine, which rises through the hypobromite of sodium solution, evolving the gas which rises to the upper part of the tube.

Each division indicates 0 001 gramme of urea from 1 cubic centimetre of urine, and the percentage is obtained by multiplying the result by 100

A knowledge of quantitative analysis of urea is very important to the physician in cases of Bright's disease

URIC ACID

TESTS

1 GARROD'S THREAD TEST —Concentrate fluid. Place 5 c c in a watch glass, add ten drops glacial acetic acid Place thread in fluid, and leave in cool place for twenty-four hours, to allow crystals to form

2 MUREXIDE TEST —Place five drops of urine in porcelain capsule Add one drop of nitric acid Evaporate gently, nearly to dryness Add small drop of ammonia= purple colour, due to murexide or purpurate of ammonia

CRYSTALS OF URIC ACID

Rhombic crystals of many different forms of yellow colour thus —Lozenge, oval, rods, spikes, fan-shaped, rosette-shaped bodies Uric acid is increased in all febrile conditions During an acute attack of gout it is almost invariably diminished in quantity, but there is a considerable increase above the normal after the paroxysm has passed off.

PHOSPHATES.

1 TESTS —Heat urine in test tube becomes cloudy and turbid, which disappears on cooling, or adding cold nitric acid to it, which distinguishes from presence of albumen

2. AMMONIUM MOLYBDOTE TEST —Place five drops of urine in test tube, add five drops of nitric acid, forty drops of ammonium molybdote solution, and heat to temperature of hand, but don't boil=a yellow precipitate. Phosphorus in urine is increased in diseases of nervous affection, in early stages of phthisis, in diabetes mellitus It is diminished in ricket, gout, rheumatism, and in renal diseases

CHLORIDES.

TEST.

Silver nitrate with a few drops of nitric acid give white precipitate The reason for putting nitric acid is, it prevents precipitation of phosphate In acute pneumonia, the quantity is greatly diminished or totally disappeared The appearance of chlorides in pneumonic urine is a good sign in prognosis of the case Chlorides may roughly be estimated, whether they are diminished or not, by comparing with normal urine

THE ABNORMAL SUBSTANCES IN URINE.

ALBUMEN

1 If urine turbid—heat If turbidity disappear, it is due to *urates* If reappear when fluid still more heated, it is due to precipitate of albumen or earthy phosphates Add nitric acid to it, if precipitate remains, it is albumen, if it disappears it is due to phosphates

2 NITRIC ACID TEST —Take cold nitric acid in test tube and pour urine slowly in it Cloud of coagulation of albumen appears

3 PICRIC ACID TEST —If urine alkaline, acidulate with acetic or citric acid, then add equal volutile solution of picric acid, there is precipitate of albumen, and becomes denser on boiling

QUANTITATIVE ESTIMATION OF PROTEID IN URINE —By means of *Esbach's process* The *reagent* used—picric acid

THE APPARATUS

A special tube holding about 20 cubic centimetres, which is marked by a line, and the letter "U" to indicate the quantity of urine to be used, and another line higher up with the letter "R" to show how much of the reagent is to be added to the urine At the lower part of the tube are lines marked by the figures 1, 2, 3, 4, 5, 6, and 7, to indicate the result The tube is provided with an india-rubber stopper

THE PROCESS

The urine must be acidulated first Fill the tube with the urine as far as the letter "U," and add the reagent until the fluid reaches the letter "R" Close the tube by means of the stopper, gently turn it upside down twice without shaking, and lay it aside for twenty-four hours, at the end of that period read off the height of the coagulation as shown by the figures at the lower end of the tube The figure represents the number of grammes of proteids contained in a litre of urine.

BLOOD

GUAIACUM TEST

Take urine in test tube, and add three or four drops tincture of guaiacum and mix, then add a little ozonic ether to form a layer on the surface It becomes blue

MICROSCOPIC EXAMINATION

In case of hæmaturia, blood corpuscles are seen, and in case of hæmoglobinuria, débris of corpuscles are to be noticed.

BILE

TESTS FOR BILE ACIDS

PETTINKOFER'S TEST —(1) Take urine in test tube (2) Add three or four drops syrup of cane sugar, and mix

(3) Slowly pour strong sulphuric acid (H_2SO_4) till purple colour is produced

In testing urine for bile acids, it should first be tested for albumen, which, if present, should be removed by heating and filtration

TEST FOR BILE PIGMENTS

GMELIN'S TEST—Place a few drops of urine on a white porcelain plate, and near it put a few drops of fuming nitric acid When two fluids are in contact with each other, the play of colour is exhibited

SUGAR.

Urine pale, specific gravity above 10 25, quantity above the normal

TEST FOR SUGAR

1 MOOR'S TEST—Add to urine equal quantity of caustic potash in a test tube, hold the tube from the bottom and boil for some time, a ruddy brown is developed in the heated zone

2 TROMMER'S TEST—Add to urine one-eighth of its bulk caustic potash, and eight to ten drops copper sulphate solution Shake and heat, a reddish-yellow colour is produced

3 PICRIC ACID TEST—Add to urine picric acid and half its caustic potash and heat, mahogany-brown colour is produced

4 FEHLING'S COPPER TEST—Put $\frac{1}{4}$ inch Fehling in test tube and $\frac{3}{4}$ inch water Boil If no change in colour, drop in diabetic urine, and, if necessary, heat again, orange colour developed

N B—Fehling's solution should be prepared from its component solutions shortly before use When it is kept for long, the tartaric acid is converted into racemic acid, on heating which reduces cupric oxide Therefore before testing the urine, the solution should be heated, and if presents change in colour, it is of no use

5 PAVY-FEHLING SOLUTION

Solution contains ammonia that prevents precipitation of cuprous oxide. This is to be used in the same way as Fehling's solution The presence of sugar is indicated by disappearance of blue colour

THE QUANTITATIVE ESTIMATION OF SUGAR

1. BY MEANS OF FEHLING'S SOLUTION

For this method a graduated burette and stand are required

The process is conducted in the following way —

Take 10 cubic centimetres of Fehling's solution, dilute it with 40 cubic centimetres of distilled water, and boil Place 10 cubic centimetres of urine diluted ten times with water in the burette, and from this drop half a centimetre into the hot Fehling's solution A yellow or red precipitate will fall at once at the bottom After it has subsided, add another half centimetre, and so on until all the blue colour has disappeared The exact moment of its disappearance must be noted If 10 cubic centimetres of urine are required to decolorise all the diluted Fehling's solution, which is equivalent to 5 gramme of glucose, the 10 cubic centimetres contain exactly this amount. From this it is easy to calculate the percentage as follows —

10 . 100 : 5 5

the urine will contain 5 per cent. of sugar

N B—This is a more accurate and speedy method of obtaining quantity of sugar present in urine One cubic centimetre of Fehling's is equivalent to 0 05 of a gramme of sugar

2 BY FERMENTATION TEST

It is proceeded with thus —

(*a*) Collect the total quantity of urine passed in twenty-four hours

(*b*) Place 4 ounces of this in an 8-ounce bottle with a small piece of German yeast, and 4 ounces in a similar bottle without any yeast

(c) Lay the bottles corked aside in a warm place at a temperature of 80° F for twenty-four hours

(d) Then take the specific gravity of the fermented and unfermented urine It will be found that the fermented urine has a lower specific gravity than the unfermented It is ascertained that for each grain of sugar per fluid ounce, one degree of density is lost by the process of fermentation thus —

Fermented specimen = 1010
Unfermented specimen = 1040

Loss—30, i e, 30 grains of sugar per ounce

This quantity, 30 grains, multiplied by the number of ounces of urine passed in twenty-four hours, will give the amount of sugar passed daily Thus, if 100 ounces of urine are passed, $100 \times 30 = 3{,}000$ grains of sugar excreted

THE EXAMINATION OF DEPOSIT OF URINE

1 DEPOSIT OF MUCUS —Allow the urine to settle in a cylindrical glass, a cloud of mucus invariably forms It may be mixed with pus or blood It is always light, and moves easily with the fluid If acetic acid is added to mucus, it produces a deposit of stringy mucin

2 DEPOSITS OF URATES —It is usually of a brick-dust colour, and moves easily when the vessel is inclined The application of heat to urine containing urates causes them to dissolve The deposits of urates are of two forms, viz, amorphous and crystalline

AMORPHOUS URATES have no great clinical significance, such deposit is formed in cold weather

CRYSTALLINE URATES are composed of urate of sodium and urate of ammonium

URATE OF SODIUM forms a greyish or yellowish deposit It is most commonly found in gouty conditions and in the pyrexia of childhood

URATE OF AMMONIUM is thrown down as a deposit during the alkaline fermentation of the urine It has no clinical importance

3 DEPOSIT OF EARTHY PHOSPHATES has usually a white or dirty-white appearance, and is somewhat heavy If the deposit is slimy, it probably contains much mucin or pus

4 DEPOSIT OF PUS —When pus is present in acid urine, it forms an opaque white deposit, but in alkaline urines it occurs as a gelatinous ropy Liquor potassæ forms with pus a viscid ropy substance like the white of an egg It is a useful test, as it distinguishes from mucus

MICROSCOPIC EXAMINATION for blood, epithelium, tube-casts, pus, sperms, micro-organism, cystin oxalate of lime, leucin and tyrosin, triple phosphate

1 EPITHELIUM AND MUCUS —The light flocculent deposit found in healthy urine consists of epithelial casts shed from all parts of the urinary tract and held together by the mucus, in women, flattened from the vagina will probably be added

2 TUBE CASTS consist of either fibrinous or blood-casts of the tubules, variaties —granular, waxy, fatty, blood-casts

3 PUS CELLS can be recognised under microscope without much difficulty

4 SPERMATOZOA—are easily recognised by their characteristic tadpole appearance They are physiologically present in the urine after connection or a nocturnal emission, but in certain cases as the result of masturbation or excessive intercourse—more rarely, however, than is popularly believed, they may be seen after straining at stool or at the end of micturition The whitish fluid passed in many cases of so-called spermatorrhœa has been found to be more often prostatic than seminal

5 MICRO-ORGANISMS—in urine frequently are found They may be recognised after culture

6 PARASITE —Ovum of the bilhorzia hæmatobia, associated with hæmaturia, of three kinds—

(1) A few drops of blood at the end of micturition when parasite lodges in the prostatic part of the urethra

(2) Whole of urine bloody, parasite in bladder

(3) Blood always flowing Parasite low down in urethra

EXCRETION OF SWEAT-GLANDS

THE SKIN, HAIR, AND NAIL

THE STRUCTURE OF THE SKIN —The skin consists of—

Two main layers —

I The *epidermis* or *cuticle*

II The *dermis*, corium, or *cutis vera* with the papillæ

I THE EPIDERMIS—consists of many layers of stratified epithelial cells

It is divided again into—

(1) Cuticle or horny layer consisting of hard flattened scales, without nuclei This again consists of *stratum corneum* and *stratum lucidum* This is thickest part of the epidermis, especially on the palms and soles

(2) *Rete mucosum* or *rete Malpighii* consists of nucleated epithelial cells The cells are irregular in shape (prickle cells) which contain pigments in the dark races This constitutes *stratum granulosum* and *stratum Malpighii*.

Thus the whole layers are—

Epidermis	(1) Cuticle.	Stratum corneum Stratum lucidum
	(2) Rete mucosum	Stratum granulosum Stratum Malpighii

The pigments in the dark races exist in the cells of the deepest layers of the stratum Malpighii

II THE DERMIS OR CUTIS VERA OR CORIUM — It is composed of ordinary areolar tissue with dense fibrous tissue It consists of—

(1) A PAPILLARY LAYER —This consists of a strong framework of connective tissue raised into papillæ The papillæ in the palms and soles are largest arranged in rows The papillæ may be vascular or nervous In the nerve papillæ are the end organs of the *sense of touch* (touch corpuscle), in the vascular papillæ are found *looped capillaries* of blood-vessels and lymphatics.

(2) THE RETICULAR LAYER —Here the connective tissue is loose, and in its meshes are *hair-follicles, sweat-glands,* and masses of fat

THE BLOOD-VESSELS OF THE SKIN

The blood-vessels are very numerous, and form plexuses round the fat cells, sweat-glands, and hair-follicles They send branches into the papillæ The lymphatics are also numerous, and form a network just beneath the blood capillaries, and communicate with larger vessels There are no blood-vessels in the epidermis, it is fed by the lymph

NERVES OF THE SKIN

Many of the papillæ are seen to contain well-marked nerves and "*end organs*"

END ORGANS ARE—

(1) End bulbs, *e g*, in the glans penis, and red borders of the lips

(2) PACINEAN BODIES—in the subcutaneous tissue, on planter and palmar nerves

(3) TACTILE CORPUSCLES—in the papillæ of the skin where touch is most acute

THE NAIL

The nail consists of a root and body The *root* is that part which is covered by the skin The whole under surface of the nail rests upon the *nail-bed,* and the lateral and posterior edges lie in the nail-groove The body is the uncovered part, which ends at the free edge The whitish portion near the root is the *lunula,* as the part is less vascular

THE STRUCTURE OF NAIL

The nail consists of the several layers of epidermis The hard and dry part corresponds to the horny layer of the skin, the matrix or nail-bed to the rete Malpighii The matrix is very vascular, and the papillæ are large and numerous At the root and sides it is continuous with the cuticle

GROWTH OF NAIL

Nail grows by constant generation of cells at the root and under-surface, and each series is followed by others, and are thus pushed forwards and become flat and horny, hard and dry

A HAIR

A hair consists of shaft or stem, and bulb or root

1 THE SHAFT —This is cylindrical and made up of a cuticle It constitutes a cortex with longitudinal streaks and a pith formed by little clusters of angular cells with pigment granules

2 THE ROOT —This is softer than stem, and swells out below into a root-bulb resting on a papilla The bulb consists of soft growing cells, and these cells proliferate for the growth of new hair The hair is lodged in a recess of the skin called the hair-follicle, the follicle receives the ducts of the sebaceous glands

COVERINGS OF A HAIR-FOLLICLE

It is arranged from without inwards—

1 Dermic coverings, continuous with the derma or cutis vera—

(1) Longitudinal fibrous layer

(2) Transverse fibrous layer

(3) Hyaline layer, transparent, homogenous, with transverse markings

2 Epidermic coverings, continuous with the cuticle—

(1) Outer root sheath, being a continuation of the rete Malpighii of mucosum

(2) Inner root sheath, corresponding to the horny layer of the skin, and has the following layers —

(*a*) Henle's layer

(*b*) Huxley's layer.

(*c*) Cuticle of the root sheath.

GROWTH OF A HAIR —The papilla on which root-bulb rests is very vascular, the cells here proliferate, and these cells represent the matrix of the hair Layer after layer is formed, and gradually the hair formed, and gradually the hair is raised higher within its follicle

CAUSE OF HAIR TURNING GREY

Grey hair is due to loss of pigments in the cortical part and air cavities are developed in it

MUSCLE OF HAIR-FOLLICLE

The muscle consists of two or three bundles of non-striped muscular fibres arranged like fan called *Arrector pili* The fibres arise from the cutis vera, and are inserted into the outside of the follicle below the sebaceous gland When this muscle contracts, squeeze out the fluid out of sebaceous gland, and also raises and erects the hair termed goose-skin Cold, electricity or fear may cause the muscle to contract to raise the hair

THE GLANDS OF THE SKIN

1 THE SEBACEOUS GLANDS.

These glands are small saccular glands which open into a hair-follicle by a duct, usually two into each follicle They are placed in the substance of the true skin They are composed of a basement membrane lined with secretory cells The secretion *sebum*, consists of epithelial cells that have undergone fatty degeneration, the protoplasm being changed into fatty matter The secretion lubricates the surface of the hair and prevents it from falling

2 THE SWEAT-GLANDS

The sweat-glands are abundant over skin These glands are coiled tube They are situated in the cutis vera (dermis), and the excretory portion is winded in the dermis like wave, and the duct is opened in the epidermis like corkscrew

THE STRUCTURE OF THE GLANDS

Each gland-tube consists of a basement membrane lined by cells The lower two-thirds of coil, the gland proper (secretory part), consists of from within outwards

(1) Columnar epithelium, with linear striation
(2) Layer of non-striped muscle
(3) Basement membrane

The structure of upper one-third of coil (the excretory part) from within outwards

(1) Transparent homogenous membrane
(2) Two or three layers of cubical cells
(3) Basement membrane

THE FUNCTIONS OF THE SKIN

1 Protective to the delicate structure beneath
2 An organ of the tactile sense
3 Excretory apparatus
4 A regulator of temperature
5 It may also absorb certain substances

1 SKIN AS A PROTECTIVE

(*a*) The subcutaneous fatty tissue gives more rounded appearance of the body

(*b*) It also protects delicate parts from external violence, more by virtue of having organ of sensation

2 AN ORGAN OF THE TACTILE SENSE

The terminations of sensory nerves in the papillæ of the cutis vera are the touch-corpuscles

3 SKIN AS EXCRETORY APPARATUS.

The skin has the following secretory functions —

(1) The secretion of sebaceous matter
(2) The secretion of sweat
(3) The respiratory excretion (CO_2)

(1) THE SEBACEOUS SECRETION

The fluid secreted from the sebaceous glands is an acid secretion and consists of fatty matters and fatty acids The skin of the fœtus has a thick coating of this substance—the "vernix caseosa" It consists of saponified fats

FUNCTION OF THE SECRETION

It helps to prevent the hair from falling, and makes the hairs and skin soft and flexible

2 THE SECRETION OF SWEAT

The sweat is secreted in the coil of the sweat-glands It is obtained pure from the palm of the hand or the sole of the foot, as there are no sebaceous glands There are two kinds of perspiration, viz —

(1) INSENSIBLE —As long as the secretion of sweat is small in amount, it passes away at once in vapour, and is always taking place

(2) SENSIBLE —As soon as the secretion is increased, it remains on the skin and forms visible drops of fluid

CHEMICAL COMPOSITION OF SWEAT

It is a clear alkaline fluid, with a peculiar odour and saline test It contains 2 per cent of solids and water which is increased by copious draught

SOLIDS ARE—

(1) Salts (sodium and potassium chlorides)
(2) Fatty acids (acetic, formic, butyric)
(3) Fats and cholesterine
(4) Nitrogenous bodies (ammonia, urea) Sometimes abnormal constituent is found in sweat, *e g*, uric acid, bile pigments, grape sugar and albumen In uræmic condition (anuria in cholera) urea has been found crystallised on the skin

SECRETION OF SWEAT

The amount of sweat secreted daily is one-sixty-fourth of the body weight Perspiration varies in different individuals The following conditions influence the secretion —

(*a*) Increased temperature of surrounding atmosphere makes the skin red, and there is profuse secretion of sweat On the contrary cold arrests the secretion

(*b*) Increase muscular activity (exercise) increases perspiration.

(*c*) A copious draught of warm water increases the secretion of sweat.

(*d*) Certain drugs favour sweatings, as pilocarpin, camphor, ammonia compounds, while atropine and morphia diminish the secretion It is important to note that when secretion from kidney and evacuation of the bowels are increased, there is diminution of secretion from the skin It is a natural antagonism existing between kidney and skin It is well known that in summer, when the skin is active, at the same time kidney is less active And on the contrary, in winter, the kidney excretes more water, and the skin is less active, cold and bloodless

NERVES MECHANISM IN SECRETION OF SWEAT

There are two sets of nerves concerned in secretion, in this respect resembling the salivary glands—

(1) Vaso-inhibitory to dilate the vessels
(2) Secretory nerve proper

This is shown by the fact that if sciatic nerve of a cat is cut, and the lower end is stimulated, it is noticed—

(1) There is great dilatation of vessels
(2) There is also secretion of sweat

This experiment is performed after giving an animal a dose of atropine (as atropine paralyses all the secretory nerve fibres) There is vascular dilatation, but no secretion of sweat This fact supported that there are two sets of nerves concerned, so the skin may be red and hot

and yet perfectly dry, or again pale and cold and covered with sweat.

SWEAT CENTRES.—The principal centre is placed in the medulla oblongata. The second is in the lower part of the spinal cord. When medulla oblongata is stimulated, all four feet of a cat sweat even after death. Cut the spinal cord in the dorsal region, and place the animal in a hot chamber, the pad of the feet sweat; cut the roots of the nerves going to the limbs, and there is no more sweat. Hence, the lower part of the cord must contain sweat centres. The course of the nerve fibres are the same as of the vaso-motor.

EXCITING CAUSE OF THE SWEAT GLANDS.

Heat is the normal stimulus. It acts upon the sweat centres, not upon the sweat glands directly. Though vascular dilatation due to the heat, usually accompanies perspiration, yet the secretion of sweat is independent of this dilatation.

4. A REGULATOR OF TEMPERATURE.

Skin is a bad conductor of heat, and thus acts as one of the factors in regulating the radiation of heat, therefore the temperature of the body. When the surrounding atmosphere is warm, the cutaneous vessels are dilated, the amount of sweat increased, and the amount of evaporation augmented, and all these tend to cool the blood. The dilated vessels also expose a larger amount of blood to the air.

When the atmosphere is cold, the cutaneous vessels are constricted, perspiration is scanty, evaporation less, so that there is less heat lost. It is in these ways that the skin acts as the great regulator of temperature.

Sudden exposure from heat to cold, thus arrest of sweating, may prove dangerous, as some internal organ may become congested, *e.g.*, the lungs, causing pneumonia, or the kidney, causing acute nephritis, due to the sudden chill, forcing the blood in upon internal organs.

5 IT MAY ALSO ABSORB CERTAIN SUBSTANCES

The skin is unable to absorb any substance, either salts or vegetable poisons, from watery solution of these This is due to the fat normally present on the epidermis An abraded or inflamed surface (after blister) of the skin absorbs very rapidly Skin absorbs fatty substances (Cod-liver can be rubbed into the skin of infants when unable to take by the mouth) When an ointment is rubbed into the skin so as to press into the pores of the skin, absorption occurs, *e g*, mercurial ointments or potassium iodide in an ointment Skin absorbs volatile substances, and when such fluids are applied to the skin by means of spray, absorbs quickly Drugs applied on the painful area diminish the pain readily When drugs injected into the skin by means of hypodermic syringe absorbed more promptly than from the stomach

Drugs may be applied by galvanic conduction through the skin If the two electrodes of a constant current be impregnated with watery solution of the drugs and applied to the skin, and if the direction of the current be changed from time to time, drugs may produce own action

EFFECT OF VARNISHING THE SKIN

In the case of the rabbit It always dies in a day or two This is not due to the loss of heat, because even though it be covered with cotton wool, or kept in a warm chamber, it still dies It is due to the retention within or the re-absorption of the constituent of the sweat and a kind of blood-poisoning, with fever, results When sweat is injected into the blood, fever and death results

CHAPTER X.

ANIMAL HEAT, METABOLISM AND DIETICS.

ANIMAL HEAT

The heat generated from the animal bodies is as a result of oxidation and splitting up of proteids and tissue metabolism The total amount of heat in the body is estimated by calorimeter which contains water When heat is added to water by an animal gives the amount of heat

METHOD

Place a rabbit in a cage The cage is placed in a large vessel, which is placed within another vessel, and the interspaces filled with water The whole thing should be enclosed in a large box packed with fur, shavings, feathers, or other bad conductor of heat A tube opens into the inner space, and from it there is an exit-tube which winds many times in the water space beneath The temperature of the water is ascertained by thermometer.

SOURCES OF HEAT

1 Oxidation is the great source of evolution of heat The food-stuffs, which are used, consist of C, H, O, N, so that in the body splitting up of this complex molecules takes place Thus—Combustion of C into CO_2, of H into H_2O, whereby heat is produced The O necessary for these purposes is absorbed during respiration and the consumption of O gives rise to production of heat The friction of the current of air in the respiratory organs also gives rise

2 TISSUE METABOLISM —When work done by internal organs is not transformed outside the body produces heat.

3 Wherever there is friction produces heat

4 MUSCLES —Much heat is produced in muscles The production of heat is due to chemical change which goes on

in muscle The muscular exercise greatly increases the metabolism and the CO_2 is excreted, but at the same time, there is a great increase in heat-production

5 The liver and alimentary canal also produce heat

ESTIMATION OF HEAT

Heat of the body is measured by the following methods —

(1) By the ordinary thermometer, or by the "surface thermometer"

(2) By thermo-electric method This method is employed in physiological investigation of heat of the body

CLINICALLY —Ordinary thermometer (self-registering) is employed The mouth and axilla are the chief two seats where the thermometer is adjusted to investigate the temperature of the body In young children it is better as a rule to take it in the groin Temperature in the mouth is a degree higher than in the axilla The temperature of the axilla is normally one degree below that of the rectum In some special cases it is necessary to take it in the rectum

PHYSIOLOGICALLY —Thermo-electric method is used, because this method measures very small amount of heat produced by a single muscular contraction, or the difference in temperature between the two sides of the heart

(For detail description of this method, read Text-book)

THE TEMPERATURE OF ORGANS

The temperature in different organs is not uniformly the same, the temperature in different organs varies The temperature of the blood is 99° to 100° F. The venous blood in internal viscera is warmer than the arterial The left side of heart is much colder, it may be explained by the blood becoming cooled in its passage through the lung during respiration

THE MEAN TEMPERATURE OF THE BODY

In the axilla, 98 6° F

In the mouth under the tongue 99° F, *i e*, a degree higher than in axilla

VARIATION OF THE TEMPERATURE IN HEALTH

1 AGE —Up to 14 years it is about 1° F higher later, it is only about ½° F, and gradually falls till 40 years of age, and then stops In old age it may again rise a little It is higher in the child and infant, because of the more active tissue metabolism

2. PERIOD OF THE DAY —Lowest between 2 and 6 A M, and the highest between 5 and 8 P M It may vary from 1 to 3° F

3 FOOD —A rise after meals

4 AFTER HÆMORRHAGE —If great, the temperature falls from ½ to 5° F the red corpuscles are lost, and therefore less oxygen is carried to the tissue

5 MENTAL EXERTION —A rise during or after vigorous mental work

6 MUSCULAR EXERTION —A rise after muscular exercise

7 TRANSFUSION OF BLOOD —After half an hour from an artery to vein raises the temperature which disappears itself

8 CLIMATE AND SEASON —This causes very little variation Why is this?

(*a*) Because the temperature is to a great extent self-regulating

(*b*) Because one can put on or take off clothing according to circumstances A person can go from a cold to a hot climate without much variation of temperature The difference is very trivial In the tropics the temperature is apt to be more excitable, and while in the temperate zone the temperature of the body during a cold winter is usually lower than it is on a summer day, it is not so excitable

9 The temperature is increased in fever It causes number of respiration and heart-beat to be increased At the same time pulse runs faster

10 The temperature is diminished in diseases. It may be due to either lessened production of heat or to increased expenditure of heat In general paralysis in some several weeks before death the temperature falls In diabetes and cholera the temperature falls The heart-beats diminish in number, while pulse becomes slower.

EQUALISATION OF TEMPERATURE

The body temperature of a person is constant, in whatever variation of temperature of surroundings he is exposed A man passes from the equator to the pole, but his temperature is the same at both places In order to maintain the mean temperature of a body, some mechanism must exist in the body The *production* and *expenditure* of heat of the body is regulated by self-mechanism

EXPENDITURE OF HEAT —The surplus heat of the body is lost by the following sources —

(1) Through the skin by *radiation* and *evaporation* 77 per cent

(2) Through respiratory passages 20 per cent

(3) Through the kidney and alimentary canals 3 per cent

1 THROUGH THE SKIN —The heat lost by the skin varies with the dilatation of the blood-vessels and the secretion of sweat When the vessels are contracted, there is less secretion of sweat, and therefore the loss of heat is diminished, much water flows from the kidney. When the vessels are dilated, the reverse obtains Increased secretion of sweat favours the loss of heat because of its evaporation

2 THROUGH RESPIRATORY PASSAGES

Heat is chiefly lost from the blood-vessels of the nose, pharynx, trachea, and bronchi, and very little from the blood in the pulmonary capillaries

REGULATION OF MEAN TEMPERATURE OF A BODY IN ALTERING TEMPERATURE OF SURROUNDINGS

The temperature is regulated in different climates by

self-regulating mechanism, viz —

(1) Variations in the loss of heat chiefly by the skin

(2) Variations in the production of heat

VARIATION IN THE LOSS OF HEAT IS BROUGHT ABOUT BY—

1 CHIEFLY LOSS THROUGH THE SKIN—

(*a*) The blood-vessels are dilated

(*b*) Much sweat is produced, and much heat abstracted from the blood to evaporate it In perfectly dry air the body can stand a temperature of even 260° F, because the rapid evaporation from the surface keeps the temperature low If the air be moist the case is different, 120° F is the highest that can be borne, so the skin presents a large surface for radiation and conduction of heat and evaporation of sweat, as well as exposing a large volume of blood to the cooling effect of the atmosphere

2 LOSS BY RESPIRATION—

The breathing becomes more rapid, as the warm blood acts on the respiratory centre, and we get a form of "heat-dyspnœa" This occurs in high degree of fever

VARIATION IN THE PRODUCTION OF HEAT IS BROUGHT ABOUT BY—

(1) By the nature and the amount of the food consumed, *e g*, much fat and animal food are consumed in cold countries, and much carbo-hydrates are consumed in hot countries

(2) By natural regulation of circulation of blood in the interior of the body

(3) By the amount of physical exercise

(4) By the nature and the amount of CLOTHING

CLOTHING —Warm clothing is equivalent of food As clothes are intended to keep in the heat of the body, and heat is produced by the combustion and oxidation of the food, the body takes in heat directly from the food, while clothing prevents it from giving off too much heat

Those forms of clothing which conduct heat badly to keep us warmest—hare-skin, beaver-skin, sheep's-wool,

cotton-wool are worst conductor of heat, consequently these substances are best suitable for cold climates .

The following substances are best suited clothing for hot climate as possessing the property of permeability for air —flannel, buck-skin, linen, silk, leather, wax-cloth

Flannel next the skin is not so easily moistened, nor does it so rapidly become cold by evaporation, hence it protects against the action of cold Dark materials absorb more heat from the sun's rays than light coloured ones Radiation from the skin depends upon person's clothing

ATMOSPHERIC INFLUENCE UPON THE BODY

EXTERNAL COLD —Cold causes the cutaneous vessels constricted, while the splanchnic areas (interior of the body) are dilated, and blood is thus drawn from the surface to the interior of the body The skin becomes pale, less soft, no sweat, the epithelium becomes dry, and does not permit fluids to pass through it to be evaporated, so that the excretion of heat is diminished Cold surroundings increase the amount of CO_2 excreted, and thus there is an increase in the production of heat, while at the same time O consumed is increased Many animals which live in very cold air or water are protected from too rapid excretion of heat by a thick layer of fat under the skin Man provides for a similar result by adapting summer and winter clothing

EXTERNAL HEAT —Heat produces the opposite effects In this case the surface vessels are dilated and greater amount of blood is drawn in the skin The skin becomes red, congested, and soft, it contains more fluids, and becomes a better conductor of heat the epithelium is moistened, and sweat appears upon the surface and heat is carried off quickly By these means the temperature of the body is kept pretty uniform, notwithstanding unequal loss and unequal production of heat

THE EFFECTS OF sudden appearance from hot surroundings to excessive cold media has been described in preceding pages (*vide* Skin)

THERMAL NERVES AND CENTRES

1. The heat-production is controlled by nerves arising from centres in or near the corpus striatum

2. The heat-loss is also under the control of the nervous system in the medulla oblongata

3 THERMOTAXIC MECHANISM —There is part of the cerebrum whose function it is to maintain the balance between the heat-production and the heat-loss

Heat-regulation, heat-production, heat-loss, may one and all be disturbed in fever It is assumed by the fact that the poison of specific fever enters the blood and affects nervous centres producing fever Further, the discharges from wounds may be absorbed into the system and induce fever, while injuries to the nervous centres, as the result of blows or falls, may cause an increase of temperature even without external wounds

FEVER —Fever consists of a disorder of the body temperature, and at the same time there is a great increase of tissue changes and oxidation Of course there is disturbance in the mechanism of heat-production and heat-loss, and diminished excretion The existence of fever may be caused by various sources, and each of which interferes in the machinery of maintenance of mean temperature, *e g*, septic fever caused by wounds, &c, the poison of which circulates in the heat regulating centre, thus fever

PHYSIOLOGY OF DIFFERENT STAGES OF FEVER—

1 COLD STAGE —When the loss of heat is greatly diminished, but at the same time the heat-production is increased

2 HOT STAGE —The heat given off from the congested red skin is greatly increased, but at the same time more heat is produced

3 SWEATING STAGE —The excretion of heat through

the red moist skin and evaporation are greatest, more than two or three times the normal

THE EFFECT OF FEVER —Increase in the intensity and number of the heart-beats and respiration, diminished digestive activity and intestinal movements and disturbances of cerebral activities The treatment of general fever falls in the range of practice of medicine, but a few physiological hints regarding it will be laid down here

EMPLOY MEDICINE TO—

(1) Diminish heat production

(2) Increase heat loss

(3) Help the secretory organs

(4) Keep the heart going

APPLICATION OF HEAT —The heat as warm bath may be applied to entire surface of the body, where the bodily temperature has fallen, or is likely to fall, as in the alleged stage of cholera, and in infants born prematurely Half-hot bath may be given to the body in case of ordinary fever, as application of heat to the skin dilates the cutaneous vessels, therefore there is evaporation of sweat and draws down the blood from congested part of the upper part of the body, thus lowers the temperature After removal from the heat, care must be taken to prevent a great escape of heat, and also sudden exposure to cold The heat may be employed by warm bath, warm packing, vapour baths, copious use of hot drink, chamber filled with heated air

Heat also is useful when the inflammation has become fully established, and suppuration is threatened This tends to localize the process, and bring the abscess to the surface For this purpose heat may be applied in the form of brocic or linseed poultices or hot fomentation to which opium may be added to soothe pain

APPLICATION OF COLD

Cold temporarily cools the skin, causing either no change or a slight rise in the bodily temperature

Cold may be applied to the whole or part of the surface of the body in the following conditions —

(*a*) In hyperpyrexia by placing the body for a time in a cold bath to abstract as much heat as possible, when the bodily temperature in fever rises so high as to be dangerous to life This result is best obtained and lasts longest when the bath is gradually cooled from a moderate temperature, as by this procedure bath is borne longer The addition of stimulating substances, *e g*, salts which cause dilatation of the cutaneous vessels, facilitates the excretion of heat

(*b*) Cold may be applied locally by means of ice-bag in cases of heat-stroke and hæmorrhage in the cranium

(*c*) Cold is of the most service in the preventive treatment of inflammation, and for controlling the process in the early stages Later, when the inflammation is fully established, it can only do mischief Its application should be continuous It is best applied in the form of an ice-bag or by irrigation with ice-cold water or by Leiter's tubes

METABOLISM

The term *metabolism* is employed to express the chemical exchange that takes place in living tissues It requires a proper kind of supply of food This food undergoes digestion, absorption, assimilation, and then form effete products which have to be given through the excretory organs

THE CHIEF WASTE PRODUCTS ARE—

Urea, carbonic acid, salts, water, uric acid

THE DIFFERENT ROUTES BY WHICH EFFETE MATTERS LEAVE THE BODY

(1) By the kidney water, urea, uric acid and salts

(2) By the skin water, and a small quantity of CO_2 and fatty matters

(3) By the lung much CO_2 and watery vapour

(4) By the alimentary canal this is chiefly the refuse matters of food, also cholesterine, hydrobilirubin part of the bile acids, and mucous

THE MAMMARY GLANDS

STRUCTURE —Each mamma is made of about 20 separate glands gathered together, each of these parts has a separate duct opening on the nipple—glactiferous ducts About 20 glactiferous ducts open singly upon the surface of the nipple Each of these just before it opens on the surface is provided with an oval dilatation—the *Sinus lactus*, these serve as temporary reservoirs of milk The glactiferous ducts, traced back lead to sacs, and these again to smaller subdivisions or acini, the acini are lined by short columnar epithelium, and inside these cells oil globules are often found

STRUCTURE OF THE DUCTS

1 Columnar epithelium—non-secreting

2 Basement membrane

3 NON-STRIPED MUSCULAR FIBRES —These fibres also form concentric circles around the base of the nipple, and some bands radiate from the base to apex of the nipple

CHANGES DURING PREGNANCY

The breasts enlarge, the state of the uterus brings about a reflex dilatation of the blood-vessels, hence hyperæmia and growth of glands tissue There is probably also some special trophic influence at work The breasts begin to secrete about the third month of pregnancy, though this is but slight till after parturition The alveoli become increased in size and number, and distended with a serous secretion The epithelial cells enlarge, oil globules are formed in their interior, which gradually pass into the fluid in the lumen to form the milk globules. Each oil globule receives an albuminous coating or cell wall

CHANGES IN THE GLAND CELLS DURING SECRETION

In the cubical cells lining the acini, the nucleus is pushed to one side by the formation of a vacuole, which then

becomes filled with oil globules, which are then discharged into the lumen of the acini, probably by a contractile extension of the protoplasm

MILK OF THE FIRST WEEK AFTER PARTURITION

It contains little casein, but much albumen, it also contains a number of compound granular corpuscles

"COLOSTRUM CORPUSCLES"—Those corpuscles are simply epithelial cells undergoing fatty degeneration Before secretion begins, the acini are filled with epithelial cells, and these undergo fatty degeneration and flow away with the first milk or "colostrum" It has a purgative action, and causes the meconcum to be discharged from the alimentary canal It is secreted for about a week

EFFECT OF EMOTIONS ON SECRETION OF MILK

Anger, grief, terror may produce serious modification in the composition of the milk or suspend its secretion altogether Milk secreted under these powerful emotions may throw the child into convulsions, and violent passion may actually make it poisonous

INFLUENCE OF NERVOUS SYSTEM

When the nipple is irritated, there is a rapid flow, and when the attention is fixed on the breasts, this serves to keep up the flow The centres for milk secretion are probably in the spinal cord, and the special secretory nerves are contained in the intercostal nerves

MILK

MILK-DIET —Milk constitutes the chief diet, not only of children up to some eighteen months of age, but also enters very largely into the food of adults Milk contains all the proximate principles necessary for a normal diet, and it is this fact that renders it so perfect a food If an adult were to live on milk alone, to get the 23 oz of dry solids necessary, he would have to take nine pints of milk daily

All milk may be regarded as an emulsion of oil globules, and to this its whiteness is due When milk is examined microscopically, it is seen to contain numerous small oil-globules floating in a clear fluid-milk-plasma. The oil-globules are very small and protected by a thin evelope of casein , they are suspended in a colourless fluid On standing, milk turns sour and curdles, this is due to the production of lactic acid, which precipitates the casein The acid is produced by the lactic acid fermentation of the milk-sugar, this being caused by the *bacterium lactis* found in the air of the dairy, adhering to vessel, &c It is not found in perfectly fresh milk

COMPOSITION OF MILK

PHYSICAL CHARACTER —Milk is an opaque, bluish-white fluid, with a sweetish taste and a characteristic odour The specific gravity of milk is 1026 to 1035, its reaction is alkaline, due to the presence of alkaline-potassium phosphate Cow's milk is also alkaline, but soon becomes acid

CHEMICAL COMPOSITION —It contains 82—90 per cent of water, and 10—18 per cent of solids varying with the animal's milk In round numbers, the water =87 5, proteid=3 5, fats=4, sugar=5

THE SOLIDS OF MILK are —proteids, fats, carbohydrates, and inorganic salts

PROTEIDS OF MILK.—There are two proteids in milk, one is called *casein*, this is the chief proteid It is coagulated on the addition of rennet *Cheese* consists of casein with fat The *curd* also consists of the casein with entangled fat, and the watery residue is called *whey* The other proteid is present in small amount, which is called lactalbumen When milk is boiled, the albumen coagulates, while the surface also becomes covered with a thin scum or a layer of casein

FATS OF MILK —Margarine, palmatin, olein, stearin, and a little quantity of fats derived from fatty acids, butyrin

and caproin. When exposed to the air, the fat increases at the expense of the casein, this is also seen in the "ripening" of cheese, where the proteids are converted into fat

When milk is beaten or stirred for a long time, the fat of the milk-globules is ultimately obtained in the form of butter, owing to the rupture of the evelopes of casein

CARBOHYDRATES —It is milk-sugar in the form of saccharose, and belongs to the cane-sugar class, having the composition $C_{12}H_{22}O_{11}$ It can undergo the "lactic" fermentation producing lactic acid Souring of milk is due to this acid

SALTS OF MILK —Salts of alkalies, potassium salts predominate, a good deal of phosphate of calcium is present

COMPOSITION—100 parts of milk contains—

———	Human	Cow	Goat	Ass
Water	90 58	86 23	86 85	89 01
Solids	12 39	13 77	13 52	10 99
Casein	3 92	3 23	2 53	3 57
Albumen				
Fat	4 30	4 50	4 34	1 85
Milk-sugar	6 09	4 13	3 78	5 05
Salts	0 28	0 61	0 65	

THE SOURCES OF DIFFERENT CONSTITUENTS

SOURCE OF FAT —It is derived from the splitting up of proteid molecules, and not from the fat taken as food The food rich in proteid increases the amount of milk and richness in fats

SOURCE OF THE SUGAR —The greatest part of the sugar is also derived from the proteids, the carbohydrates of the food have no effect on the amount of sugar in milk

SOURCE OF CASEIN —This seems to be derived from the proteids of the blood and lymph

In order to increase the quantity of milk into secretion, proteid food must be given

MILK OF DIFFERENT ANIMALS

GOAT'S MILK is nearest to human as far as composition is concerned, but it has bad odour, and forms a very dense curd in the stomach Mixed with lime water can get rid of the curd

ASS'S *MILK is good for infants, because the casein* is easily precipitated, and the curd is delicate

COW'S MILK is mostly used because it is easily procured and comparatively cheap, but the proteids are in excess, and there is too little sugar

BUFFALO'S MILK —It is rich in fat, and not so easily digestible as cow's milk

PREPARATION OF COW'S MILK FOR A CHILD

1 It has to be diluted—say one-third milk and two-thirds water

2 Add sugar of milk This is not so likely to ferment as common white sugar

3 Heat to about 100^0 F

It should not be skimmed, nor should there be any lactic acid present, *i e*, it should not be sour, as this may cause diarrhœa in the child *Boiled milk is more digestible* than unboiled, and souring of milk induces diarrhœa

EGGS are regarded excellent food in virtue of passing large amount of nitrogenous elements The yolk contains proteid and white of egg has own constituent egg-albumen Eggs are deficient in carbohydrates

FLESH is the chief food of cold climate owing to having a geater proportion of nitrogenous bodies The constituents are muscle-substance proper and fats, and the chief proteid of the contractile muscular substance is *myosin* The red colour of the flesh is due to the hæmoglobin present in the sarcous substance Amongst the salts, potash and phosphoric acid compounds are most abundant

The flesh of birds contains more proteids than that of mammals and fishes The flesh of young animals is more

tender and more easily digested than the flesh of old animals

FISH —Fish is of great value as diet It is far more easily assimilated and digested than meat It is a most useful diet in inflammatory diseases The fish is a light diet and suitable for hot climate Its nutritive function is that fifteen parts of fish are equal in nutritive value to twelve parts of beef

VEGETABLE FOODS —They are characterised by having very large amount of non-nitrogenous substances They still contain some amount of nitrogen, and the vegetable proteids do not differ from animal proteids Vegetable foods yield considerable amount of fæces

1 THE CEREALS are most important vegetable foods, they contain proteids, starch, salts and water The proteid is *glutin* This is rapidly prepared from flour by washing and kneading it in a muslin bag under a stream of water It is very sticky, and capable of being drawn out into long shreds The chief vegetable seeds enters into food are—wheat, rye, barley, maize, rice, buckwheat

2 THE LEGUMINOUS seeds contain much proteid called legumin, together with starch and water Owing to cheapness the various seeds are used as food among poorer classes of people The various seeds are—peas, gram, beans, &c, &c

3 The whole group of farinaceous substances as rice, cornflour, arrowroot, sago, potatoes are composed largely of starch

4 GREEN VEGETABLES are composed of salts which resemble the salts of blood They contain a large amount of potash salts They are used in food chiefly for the salts they contain The absence of vegetables from food causes scurvy This disease is due to absence of those ingredients (potassium salts) in the food which are supplied by fresh vegetables In arctic expeditions, in the navy, lime juice was served as a remedy for the disease

5. THE FRUITS —The chief ingredients of fruits are sugar and salts

6 TEA AND COFFEE —They are stimulant to nervous system

THE CHIEF ALIMENTARY PRINCIPLES ARE—

(1) Proteids or nitrogenous

(2) Fats or hydro-carbons

(3) Amyloids or carbo-hydrates

(4) Mineral constituents—water and various salts

(5) Accessory principles—tea, coffee, alcohol

PROTEIDS —Proteids consist of C,H,O,N,S, and the following proteids are used in food —

Albumen	Glutin (in flour)
Casein	Legumin (in peas, beans, &c)
Myosin	
Fibrin	

FATS (or hydro-carbons) consist of C,H,O They contain 80 per cent of carbon, and the following fats are consumed —

Suet	Ghee
Lard	Marrow
Butter	Vegetable oils

Amyloids or carbohydrates are composed of C,H,O, and contain 40 per cent of carbon The following amyloids are in use —

Cane-sugar	Tapioca
Grape-sugar	Arrowroot
Milk-sugar	Rice and potatoes
Starch in sago	

N B —The fats and amyloids differ In fats there is a large excess of hydrogen more than enough to form water with the oxygen present

In carbohydrate there is just enough of hydrogen to form water with the oxygen present

DIET FOR A HEALTHY ADULT

An adult requires to maintain sound health a mixture of the following groups of food-stuffs along with a necessary relish

1 Water is a necessary drink

2 SALTS —This is an important part for the tissues, and without them tissues cannot be formed If salts are avoided, nutrition is interfered with, absence of lime affects in the formation of bone Iron, which is essential for the formation of blood, exists in animals and vegetables

3 PROTEIDS of animals or vegetables are required as they are the "tissue formers"—build up the new and repair the waste They contain N

4 FATS AND CARBOHYDRATES —Owing to the large amount of C, when they undergo oxidation, they form the chief source of the heat of the body They are "energy-producers'

AN AVERAGE DIET—ONE FOR SEVERE LABOUR AND ONE FOR REST

	Average	Severe labour	Rest
1. Proteids	4½ oz	6—7 oz	2—2½ oz
2 Fats	3 ,,	3½—4½ ,,	½—1 ,,
3 Amyloids	14½ ,,	11—18 ,,	12 ,,
4 Salts	1 ,,	1¼—1½ ,,	½ ,,
5 Water	Varies		

Diets of human beings are derived partly from plants and partly from animals

PURELY ANIMAL FOOD (other than milk) does not maintain perfect health, salts are too deficient, and scorbutic results

PURELY VEGETABLE DIET is not sufficient either to maintain good health The coloured blood corpuscles become fewer, and the nervous and muscular system lose their accustomed force

BEST SUITED DIET IN VARYING CLIMATE

FOR COLD CLIMATE —One containing a large proportion of proteids, and especially of fats The total amount required will also be greater, as increased oxidation is necessary to develope the extra heat

FOR HOT CLIMATE —In hot climate the digestion becomes less able to digest fats and animal foods A large proportion of vegetable food is best

RESULTS OF STARVATION —The animal loses about two-fifths of its entire weight, and then dies The cause of death probably is the loss of heat

THE TISSUE WASTE IN ORDER

1 Adipose tissue
2 Spleen
3 Liver
4 Muscle.
5 Blood
6 Brain and spinal cord

Adipose tissue suffers most, next the glandular The nervous system loses little or nothing, because it is at the expense of adipose and muscular tissues The heart, though a muscle, loses very little, because of its great importance, and is therefore fed at the expense of other parts

EFFECTS OF VARIATION IN THE QUANTITY OF PROTEIDS

1 IF PROTEIDS WANTING—Urea and uric acid are diminished, though not entirely absent Nitrogen must be got somehow either from the tissues themselves , hence, if absent in the food, the body feeds on itself

2 IF PROTEID DEFICIENT —This leads to muscular and nervous weakness, and a tendency to low forms of inflammation and fever

3 WHEN PROTEID IN EXCESS ALONG WITH PROPER FOOD —There is a gain in weight, due to accumulation of fat The proteid food is split up into a substance that gives to urea and fat, the fat is stored up,

and the urea passes off by the urine, therefore, in an exclusively meat diet, the urea is much increased, and may give rise to gout

When carbohydrates are omitted from the food more fats and proteids are required, because there would be diminution of glycogen, and all the muscles and protoplasmic tissue require glycogen

PROTEID METABOLISM

PROTEIDS —Substances of an albuminous nature, rich in nitrogen, under the action of—

1 Saliva, they are finely divided or masticated,

2 Under the action of gastric juice they are converted into—

$$\left.\begin{array}{l}\text{(1) Acid albumen}\\ \text{(2) Albumose}\\ \text{(3) Peptone}\end{array}\right\} = \text{acid chyme}$$

3 Under the action of pancreatic juice and succus entericus they are converted—

(1) Alkali albumen

(2) Albumose

(3) Peptone

(4) Leucin, tyrosin—to a slight extent

Skatol, indol and phenol-bodies which result from putrefaction (of course under bacterial influence) are also formed Proteids are thus converted from non-diffusible into diffusible bodies termed "peptone"

FATE OF PEPTONE

Passing through the intestinal walls it is converted into albuminous bodies, and carried by the portal vein to the liver

In the liver peptone is broken up into that which is used for nourishment, and that which is to be excreted That

which is *to be excreted* undergoes the following changes —

Proteid waste

1	Group of compound	Leucin Tyrosin
2.	End product	Uric acid Urea

In other words, within the liver the waste products are converted into urea, uric acid, which escape into the blood, and are then excreted by the kidney

METABOLISM OF CARBOHYDRATES

Under the action of—

		Starch is converted into
1	Saliva	Acro-dextrin and Erythro-dextrin Maltose
2	Pancreatic juice	Maltose
3	Succus enterious	Glucose
4	In the liver	Absorbed into portal circulation as Glycogen, and pass out when required into the blood

The carbohydrates, after passing through various changes, get to the liver as grape sugar In the liver a portion is, however, stored up for a time as "glycogen" This glycogen is again converted by the liver cells into grape sugar, and then by means of stream of blood is conveyed to the various tissues

CHAPTER XI.

THE SENSES

(INCLUDING TOUCH, SMELL, TASTE, HEARING, AND THE SIGHT)
AND VOICE AND SPEECH

The senses are the means of communication between the mental or inner world of the individual and the world around him—the outer world. The necessary apparatus are—

1 Peripheral end-organs, especially adapted for stimulation by the requisite kind of mechanical energy, *e g*, contact of a body for feeling of touch, light for the eye, sound for the ear, &c

2 Nerves to convey the excitement to the—

3 Central organs or sensorium

THE SENSE OF TOUCH.

The feeling of touch arises by the application of a stimulus to the "end-organs," which are termination of sensory nerves in the papillæ of the cutis vera

TERMINATION OF SENSORY NERVES

The nerves end under the skin in minute *knob-like* swelling called "*end-organs*" in various forms They are modified epithelial cells with delicate termination of the nerve filaments

THE VARIOUS END-ORGANS ARE—

1 THE TOUCH CORPUSCLES OF WAGNER AND MEISSNER —They are oval or elliptical bodies found in the papillæ They are very numerous in the palm of the hand and the sole of the foot, especially in the fingers

2 TACTILE OR TOUCH CORPUSCLES OF MERKEL—occurs in the epidermis of man

3 PACINIAN CORPUSCLES —They are oval bodies situated in the subcutaneous tissue of the fingers, toes, and on the dorsum of the penis and clitoris Each corpuscle is attached by a pedicle to the nerve on which it is placed, and it is formed of several concentric layers of membrane

4 KROUSE'S END BULB —They are round bodies They are situated in the floor of mouth, red border of the lips, nasal cavity, epiglottis, fungiform and circumvallate papillæ, glans penis, clitoris and vagina They are composed of a medullated nerve-fibre

SENSATION —By the term "sensation" means, "a state of consciousness" produced by the higher centre of brain (mind) caused by the application of stimulus to the peripheral end of the sensory nerves

AFTER-SENSATION —This means a sensation lasting after the usual stimulus has come to an end, *e g* , look at an object for an instant, and then close the eyes the object is still seen, and its parts have the same form and colour

SUBJECTIVE SENSATION —This means a sensation felt without the usual cause or stimulus, *e g* , light seen, or sound heard, when there is neither light nor sound The subjective phenomena belonging to the nerves of sensibility are sensation of tightness, weight, sinking, heat, cold, numbness, itching, creeping, tingling, pricking, and throbbing

COMMON-SENSATION —By this term we understand pleasant or unpleasant sensation felt in those parts of the bodies which possess sensibility whose character is difficult to describe, and to this belong pain, hunger, thirst, fatigue, horror, vertigo, tickling, sexual-desire

TACTILE AND PAINFUL SENSATION —Every sensory nerve possesses two different nerve-fibres for emission of two separate functions, following —

1 FOR PAINFUL IMPRESSION —Pain may occur wherever sensory nerves are distributed, and so pain may be produced by stimulating them in any part of their course

provided stimuli are strong enough The stimuli may be mechanical, chemical, electrical, thermal, inflammation There are special *"pain-spots"* scattered in the skin

2 FOR TACTILE SENSATION —This nerve-fibre includes also to convey impression of *temperature* and *pressure* These sensations are felt when stimuli are applied to the end-organs Tactile, temperature, pressure sensations are discharged from the skin, the mouth, the floor of the nose, the pharynx, the lower end of the rectum, and genito-urinary orifices Tactile sensation is absent from all internal viscera Each of these has different spots for conveying impression

(*a*) TACTILE gives the impression of touch and the part which is touched

(*b*) TEMPERATURE gives the sense of heat and cold

(*c*) PRESSURE gives the sense of weight which is exerted on the body

MUSCULAR SENSE —The sensory nerves of the muscles supply us a knowledge of the condition of our muscles, and to what extent they are contracted, and the resistance offered by external objects

TESTS FOR VARIOUS SENSIBILITY.

1 TOUCH —Lay finger upon the patient while the eyes are shut, and ask him to point to the spot

2 PAIN —Prick or pinch the patient Thus increased and decreased sensibility may be ascertained

3 TEMPERATURE —Determine by applying hot and cold sponges, or hot and cold test tubes to the surface of the body

4 PRESSURE —Sensibility to weight may be tested by laying objects of similar appearance and size, but of different weight, upon the part under investigation Balls of leather containing different weight are commonly employed for the purpose

5 THE MUSCULAR SENSE —This may be tested in various ways Ask the patient to stand with his eyes shut and his feet placed close together, or ask him to touch his nose or other part with his fingers

SENSE OF SMELL

The nose is divided into following parts —

(1) A part on the face

(2) Nasal fossæ, separated by septum

(3) Posterior nares, opening into pharynx The mucous membrane of the nose is firmly united with the periostium and perichondrium It continues with—

(1) The skin, through the nostrils

(2) The mucous membrane of pharynx, through the posterior nares

(3) The conjunctiva, through the nasal duct and canaliculi

(4) With the several sinuses of the skull The nose is in connection with all these parts, when inflamed, therefore, the inflammation may spread to any of these parts

THE REGIONS OF THE NOSE ARE—

1 OLFACTORY REGION includes—

(*a*) Upper part of the septum

(*b*) Upper turbinated bone

(*c*) Part of the middle turbinated bone This region has thicker and non-ciliated columnar epithelium, and contains end-organs of the olfactory nerve or *"Olfactory cells"*

2 RESPIRATORY REGION —This region embraces the remainder of the nasal cavity, and it is lined by ciliated epithelium like that in the trachea

OLFACTORY CELLS —They are *end-organs* of the olfactory nerve, and they are distributed between the epithelium covering the olfactory regions The cells are spindle-shaped, with a large nucleus, sending upwards

between the columnar cells smooth rod which ends abruptly about the same level as the columnar cells If traced backwards they pass into the olfactory nerve

THE NERVES OF THE NOSE

1 OLFACTORY FIRST CRANIAL NERVE —This is special nerve for the sense of smell

2 THE FIFTH CRANIAL NERVE —This is nerve for common sensibility, heat and tactile

CAUSE OF DIFFERENT SMELLS

It is supposed to be due to different modes of stimulation of the olfactory cells

ANOSMIA —It is want of the sense of smell In such cases the olfactory nerve is usually atrophied

THE SENSE OF TASTE

The sense of taste is confined to the tongue The tongue is composed of muscular tissue covered with mucous membrane, has already been described The mucous membrane on the dorsum of the tongue is elevated These elevations of mucous membrane are called *Papillæ* These papillæ are of three kinds —

1 FILIFORM —These are most numerous and occur over the whole surface of the tongue They are minute conical covered by squamous epithelium

2 FUNGIFORM —They are not numerous They occur chiefly over the sides and tip of the tongue They are deep red colour and club-shaped

3 CIRCUMVALLATE —These are the least numerous and largest, they are from 7 to 12 in number, and are arranged in a V-shaped manner, they have numerous secondary papillæ, and in them are *taste-buds*

TASTE-BUDS OR TASTE-BULBS —These are end-organs of the *gustatory* nerves They are found—

(1) In the sides of the circumvallate papillæ

(2) In the fungiform papillæ

(3) In the papillæ of the soft palate and uvula

(4) Posterior surface of the epiglottis

(5) Anterior pillars of the fauces

They are barrel-shaped embedded in the squamous epithelium of the tongue

NERVES OF THE TONGUE

1 COMMON SENSATION

(1) To anterior two-thirds lingual branch of the fifth nerve

(2) To posterior one-third glosso-pharyngeal, and lingual filament, from the superior laryngeal branch of the vagus

2 SPECIAL SENSE OF TASTE

(1) To anterior two-thirds, chorda tympani, from portio dura of seventh cranial nerve

(2) To posterior one-third glosso-pharyngeal

3 MOTION—

The ninth cranial nerve

TASTE SENSATION —There are four different kinds—

(1) Sour, (2) Sweet } Anterior part of tongue—sour the edge, sweet the tip

(3) Bitter, (4) Saline } Posterior part of the tongue

Different taste, probably due to different modes of stimulation of the nerves of taste

CONDITION FOR TASTE REQUIRED

1 Substances must be in solution or be capable of being dissolved by the saliva

2 It is best when they are swallowed, for then the substances are pressed into the taste-buds

Diseases of the tongue, as well as dryness of the mouth caused by interference with salivary secretion, interferes with the sense of taste

TASTE TESTING.

Ask the person to put out the tongue and close his eyes. Then put a little quinine on the area tested

THE SENSE OF HEARING.

ANATOMY OF THE EAR

The organ of hearing consists of three distinct parts, named from their relative position, the *External*, *Middle*, and *Internal*

THE EXTERNAL EAR

The external ear commences in the expanded pinna, which consists of yellow cartilage covered by delicate skin By this trumpet-shaped expansion many of the sound-waves are collected, to be conducted by the column of air in the external meatus down to the drum (middle ear), the membrana tympani

EXTERNAL AUDITORY MEATUS—is about $1\frac{1}{4}$ inch long, and starting from the depth of pinna (concha), between the condyle of the jaw and the mastoid process, passes at first a little upwards and then slightly downwards until it reaches the tympanic membrane It passes obliquely forwards and inwards It is like an hour-glass, somewhat smaller at the middle than at either end The external meatus is partly bony and partly cartilaginous, the cartilaginous part measures about $\frac{1}{2}$ inch, and osseous portion $\frac{3}{4}$ inch The meatus is lined with a layer of skin Sweat or ceruminous glands and sebaceous glands are confined to the cartilaginous portion of the meatus An oily material is secreted by the gland which becomes wax of the ears

MEMBRANA TYMPANI stands at the bottom of the external auditory meatus The membrane is concave on the outer surface and convex on the tympanic side

In appearance it is pearly-grey and translucent and that the handle of malleus is also seen on its surface.

STRUCTURE OF THE MEMBRANE

It consists of three layers —

1 THE OUTER LAYER is a continuation of the skin of the meatus

2 THE MIDDLE LAYER consists of connective tissue fibres arranged both radially and circularly

3 THE INTERNAL LAYER or mucous layer, which is continuous with the mucous membrane of the tympanic cavity

EXAMINATION OF EXTERNAL MEATUS AND TYMPANIC MEMBRANE

When examining outer meatus, pull the ear upwards and backwards, the canal will be straightened to a great extent This is quite sufficient when examining the child's ear The tympanic membrane is examined by the speculum and mirror The membrane in health is seen pearly-grey and translucent with handle of malleus

FUNCTION OF TYMPANIC MEMBRANE —When sound waves enter the external meatus, they are caught by the membrane and membrane is thrown into vibration

THE MIDDLE EAR

The *middle ear* or tympanum is a small *six-sided* cavity, situated in the substance of the temporal bone It is separated from the external ear by the tympanic membrane It is filled with air and contains three small bones It communicates with the pharynx for ventilation by means of *Eustachian tube.*

BOUNDARIES

1 THE ROOF —A thin plate of bone and dura mater

2 THE FLOOR —Meeting of the outer and inner walls, just above the jugular fossa There is a small aperture in it for entrance of Jacobson's nerve

3 THE OUTER WALL is the tympanic membrane

4. THE INNER WALL constitutes the following —

(*a*) FENESTRA OVALIS—small oval opening leads to the vestibule which is blocked by the base of the stirrup

(*b*) FENESTRA ROTUNDA—It is an opening below and behind the promontory which looks into the scale tympani of cochlea It is closed by a membrane

NOTE—It is by these apertures that the waves of sound can be transmitted from the middle to the inner ear

(*c*) THE PROMONTORY—caused by the bulging outward of the first turn of the cochlea It has grooves for the filaments of the tympanic plexus

(*d*) THE PYRAMID—containing the stapedius muscle

5 POSTERIOR WALL—The openings of the mastoid cells

6. ANTERIOR WALL

(*a*) Canal for tensor tympani

(*b*) Process cochleariformis

(*c*) Eustachian tube

CONTENTS OF THE TYMPANUM

1 Air

2 Chain of ossicles—Malleus, incus, and stapes

3 Muscles acting on the ossicles

4 Chorda tympani nerve

5 Opening of Eustachian tube.

CHAIN OF OSSICLES

These three small bones are swung across the cavity as a short chain from the outer to the inner wall

MALLEUS (hammer), with its head, neck, hands and processus gracilis The handle is firmly united to the fibres of the tympanic membrane

INCUS (anvil), like a bicuspid tooth with the fangs widely separated It has a body, with a long and a short process The long process ends in the *os orbiculare,* and through this articulates with stapes

STAPES (stirrup), with its head, neck, base, and two crura the base fits the fenestra ovalis

FUNCTION —By the oscillation of these bones the vibration of the tympanic membrane is transmitted to the fluid in the internal ear

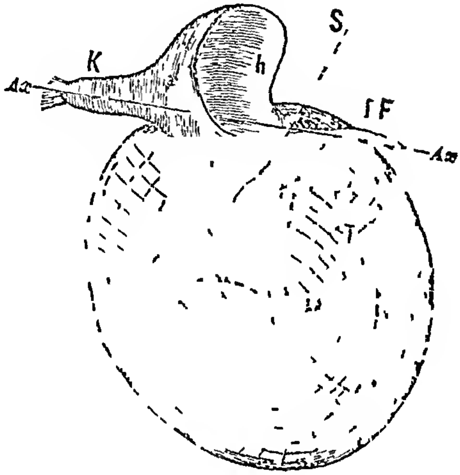


Fig 23 —Tympanic membrane and the auditory ossicles (left) seen from within, i e, from the tympanic cavity M, manubrium or handle of the malleus, T, insertion of the tensor tympani, *h*, head, *lF*, long process of the malleus, *a*, incus, with the short (K) and the long (*l*) process, S, plate of the stapes, *Ax*, *Ax*, is the common axis of rotation of the auditory ossicles, S, the pinion wheel arrangement between the malleus and incus —*Stirling*

MECHANISM OF INCUS-MALLEUS JOINT

When the handle of the malleus is drawn in, this joint is locked, and the bones vibrate as one The lower margin of the articular surface of the incus has a well-marked projection, which catches against the prominent border of the articular surface of the malleus, in this way the joint is locked, when the membrana tympani moves inwards When the handle of the malleus is moved out too much, the joint is unlocked, so that the incus need not follow, but the malleus moves outwards alone, and this prevents the stapes from being dragged out of the fenestra ovalis

MUSCLES ACTING ON OSSICLES

1. TENSOR TYMPANI.—It *arises* from the apex of

the petrous portion of the temporal bone, and cartilage of the Eustachian tube, *inserted* into the handle of the malleus, supplied by a twig from the fifth nerve

FUNCTION —This muscle locks the joint, it contracts when the ear is strained to hear faint sounds

2 STAPEDIUS—*arises* within the pyramid, and is *inserted* into the neck of the stapes, supplied by a branch from the facial nerve

FUNCTION —It tilts out one part of the foot of the stapes, and thus lessens its amptitude of vibration, and in this way protects the internal ear from painful stimulation by loud sounds

EUSTACHIAN TUBE —It is about one inch and-a-half ($1\frac{1}{2}$) in length, and runs from the junction of the squamous and petrous portions of the temporal bone forwards, inwards to the pharynx where it ends above the level of the soft palate

It consists of—

(1) AN OSSEOUS PART, about half an inch in length, situated in the temporal bone

(2) The cartilaginous part is about an inch, it is lined by ciliated epithelium, it is usually closed, but is opened at the movement of swallowing, it is easily found by curved catheters introduced along the inferior meatus of the nose

FUNCTION —It ventilates the tympanic cavity and removes the secretion from By this means the pressure of air within the tympanum is kept the same as in the external auditory meatus, so that the pressure on the two sides of the membrane is the same—a condition necessary for the normal vibration of tympanic membrane

INFLATION OF TYMPANUM

This is required in cases of deafness due to occlusion and chronic thickening of mucous membrane of Eustachian tube For the purpose Eustachian catheter is introduced into the tube along the floor of the nose

VALSOLVA'S METHOD —Hold the nose between the finger and thumb of one hand, close the mouth and expire forcibly as in "blowing the nose," and try to swallow at the same time as this opens the tube

PALITZER'S METHOD —The nozzle of air-bag is introduced into one nostril, while the other nostril is closed, and the patient is directed to swallow, while, at the same time, the surgeon compresses the bag, and the patient's mouth being closed, air is forced through the open Eustachian tube into the middle ear

THE MASTOID ANTRUM

This is an air containing cavity situated behind and above the tympanum, with which it communicates by a cleft The antrum is lined with mucous membrane This is very important for the surgeon to know the exact position, as often an inflammation and suppuration occurs therein, which may travel to the middle ear and thence to the brain.

INTERNAL EAR OR LABYRINTH

The internal ear is a labyrinth tunnelled out in the petrous portion of the temporal bone, and is situated at the bottom of the internal auditory meatus It is composed of osseous labyrinth enclosed in membranous labyrinth

OSSEOUS LABYRINTH—consists of three parts—

(1) Cochlea

(2) Semi-circular canals

(3) Vestibuli

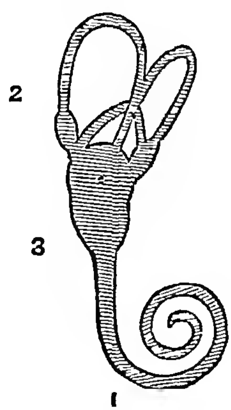


Fig 24

AND ITS CONTENTS ARE—

It contains perilymph, and the membranous labyrinth, which contains endolymph

COCHLEA

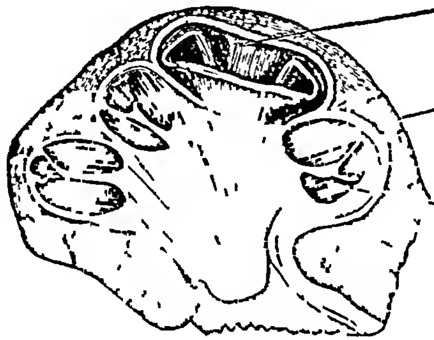


Fig 25

Vertical section of the Cochlea of a calf —*Schafer*

The cochlea is well named from its resemblance to a snail-shell It is placed horizontally in front of the vestibule, its base lying against the bottom of the internal auditory meatus It is found to consist of a central axis, the modiolus (bucket), and a canal winds for two and-a-half turns from the base to the apex

COCHLEA is a tube, divided into two compartments by a septum partly *osseous* and partly *membranous*

OSSEOUS—called lamina spiralis osseus

MEMBRANOUS—called membranous basilaris In this way two compartments are formed, the upper compartment is called *scala vestibuli* and the other is *scala tympani* The two compartments communicate at the apex through the *helicotrema*

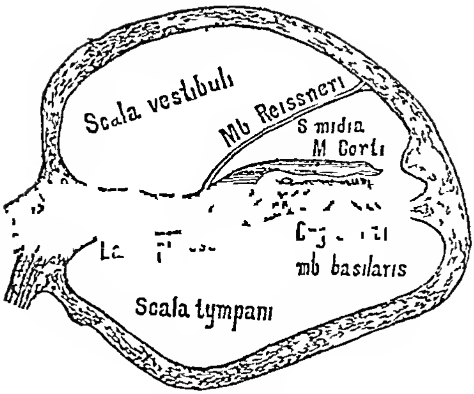


Fig 26

The scala vestibuli is further divided by a membrane called Reissner's membrane, which springs near the outer part of the lamina spiralis osseous, and runs obliquely outwards to the wall of the cochlea, and this compartment thus formed is called *scala media* The floor of this compartment is formed by the *basilar membrane* on which end-organ of the auditory nerve—"*organ of corti*" is placed The *membrana tectoria* or *membrane of corti* also arises from the outer end of the lamina spiralis It extends outwards over the organ of corti It is said it acts as damping apparatus for the organ of corti, as found in piano

VESTIBULI

The vestibuli is situated in the middle communicating with—

In front with the cochlea (through scala vestibuli)
Behind the semi-circular canals (five openings).
Outer side, the tympanum
Inner side, internal auditory meatus.

ITS WALLS

ITS OUTER WALL is perforated by the fenestra ovalis.

ON THE INNER WALL—there are small foramina which transmit twigs of the auditory nerve into the

vestibuli from the bottom of the internal auditory meatus These minute perforations are situated in a small round pit which is called the fova hemispherica

IN THE ROOF—there is another excavation called fova hemi-elliptica

SEMI-CIRCULAR CANALS

The semi-circular canals are three in number They are bony tubes above and behind the vestibuli, named superior, posterior, and external Now all these canals open into the vestibuli, we should expect to find six small apertures, but there are only 5, because the superior and posterior canals have their adjoining ends merged into a common opening

PERILYMPH —It is fluid inside the osseous labyrinth which surrounds the membranous labyrinth, so all the spaces within the labyrinth are filled by this fluid This fluid finds its way into the canal of the cochlea and occupies the scala vestibuli and scala tympani

MEMBRANOUS LABYRINTH

It is much smaller than osseous, and lies in the osseous labyrinth and contains fluid called *endolymph* In certain parts of this membranous labyrinth are placed end-organs of the auditory nerve, immersed in the endolymph

MEMBRANOUS LABYRINTH—consists of 3 parts —

(1) Vestibuli (formed by *saccule* and *utricle*)

(2) Membranous semi-circular canals

(3) Cochlea (scala media)

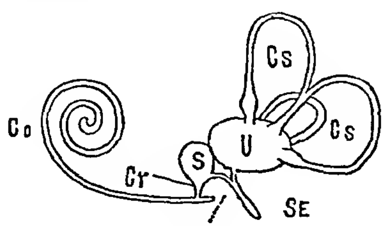


Fig 27

SCHEME OF THE HUMAN LABYRINTH

Cs, semi circular canal, *U*, utricle, *S*, saccule, *Cr*, canalis reunien, *Co*, cochlea, *Se*, saccus endolymphaticus

VESTIBULI —It consists of utricle and saccule

THE UTRICLE is the larger, and into it open the semi-circular canals, it occupies the *fora hemi-elliptica*

THE SACCULI—lies in the *fova hemispherica*, it is connected with the membranous canal of the cochlea (scala media) by the *canalis reunion* The utricle and sacculi are connected not directly, but by means of a Y-shaped tube, the *aquæductus vestibuli*

FUNCTION —It is supposed that it acquaints us with the presence of sound

MEMBRANOUS SEMI-CIRCULAR CANALS

They are about one-third the size of the osseous, one side is fixed to the wall of the bony canal and the other side is free and open into utricle In the number and shape they are the same as bony canals

COCHLEA

This is the "*scala media*" of osseous labyrinth formed by the division of the scala vestibuli The special organ "*organ of corti*" is situated on its floor

It is triangular in shape—

BOUNDARY—(1) The basilar membrane below

(2) The membrane of Reissner on the inner side

(3) The outer osseous wall of the cochlea, externally

ENDOLYMPH —It is fluid contained inside the membranous labyrinth in which end-organs are projecting

THE AUDITORY NERVE

The auditory nerve on reaching the bottom of the internal auditory meatus divides into two branches, one for the vestibuli and the other for the cochlea

VESTIBULAR BRANCH

It divides into five parts, to be distributed on utricle, sacculi and the three ampullæ of the semi-circular canals and ends in the "auditory cells" At crista acustica the

nerve terminate into delicate hair-like processes which project into the endolymph In connection with hairs are the otoliths These consist of crystals of carbonate of calcium embedded in a jelly These hairs project into the jelly, and touch the otoliths The hairs are chiefly affected by the vibration of the sounds

COCHLEAR BRANCH

The nerve enters the foramina at the base of the modiolus and terminate in connection with the cells in the organ of corti

ORGAN OF CORTI

The organ of corti is *end-organs* of the auditory nerve contained in the epithelium covering the basilar membrane

PARTS OF ORGAN OF CORTI

1 Rods or pillars of corti (between them arch of corti) are arranged in two rows, and enter whole length of membranous spiralis lamina

2 Inner hair-cells (one row).

3 Outer hair-cells (three rows) There are between them certain supporting cells called *cells of Deiters*

4 Reticular membrane (phalynges) covers the corti's rods and the hair cells The hair projects through the holes in this membrane

5 Supporting cells of Hensen

6 Membrana tectoria—It stretches over the whole length of organ of corti It acts as damper, so as to stop quickly their movements

AUDITORY CENTRE—It is situated in the superior temporo-sphenoidal convolution

TRANSMISSION OF SOUND-WAVES THROUGH EXTERNAL EAR

When waves of sound strike the auricle, they are partly reflected outwards and the remainder is directed into the auditory canal Vibrations are transmitted along the auditory canal, partly by the air it contains and partly by its walls, to the membrani tympani In the auditory canal

the waves of sound react the tympanic membrane As the membrane is oblique and curve in direction, so the waves strike it

MIDDLE EAR

The membrana tympani is capable of being set into vibration The membrane is adherent to the handle of the malleus which follows its movement The vibrations of tympanic membrane are transmitted to the internal ear partly by the air which the middle ear contains and partly by the chain of ossicles Transmission by the chain of bones is by far the most important The chain of bones is oscillated in one as the power is being applied at the handle of malleus and the resistance at the base of stapes which fits at the oval window (Fenistra ovalis) Thus the vibration of tympanic membrane is carried along the chain of ossicle, as they vibrate whole, and transmitted to the fluid in the labyrinth or internal ear through the oval window

INTERNAL EAR

When base of stapes is pushed into the oval window, the pressure in the labyrinth increases the impulse passes along the scala vestibuli to the scala tympani The fluid of labyrinth receives a series of vibration isochronous with the movement of base of stapes And these vibration affect the terminal apparatus in connection with the auditory nerve

VIBRATIONS REACH THE FLUID IN THE LABYRINTH BY THE FOLLOWING WAYS —

(1) By the osseous walls of the labyrinth.
(2) By the air in the tympanum and the round window.
(3) By the base of stapes inserted into the oval window
(4) By the bones of the head.

In deafness sound perception is tested by tuning-fork on the head or in the teeth

FUNCTION OF THE SEMI-CIRCULAR CANALS

The office of semi-circular canals is not known with certainty However they are supposed to be the peripheral end-organs of "sense of rotation"

THE SENSE OF SIGHT

THE EYE

The eyeball is contained in the cavity of the orbit, imbedded to a large extent in loose fat and with muscles attached to it, by which it is capable of being directed to any part It is supplied by vessels and nerves, and it is protected in front by eyebrow, eyelids, etc

The globe of the eye or organ of vision is a complex optical apparatus consisting of several coats and cavity filled by fluid and solid refracting media

THE CAVITY OF EYEBALL is situated behind the lens It is lined by retina and filled by vitrous humour

THE COATS OF THE EYEBALL

(1) Cornea and sclerotic.

(2) Choroid, ciliary body, and iris

(3) Retina

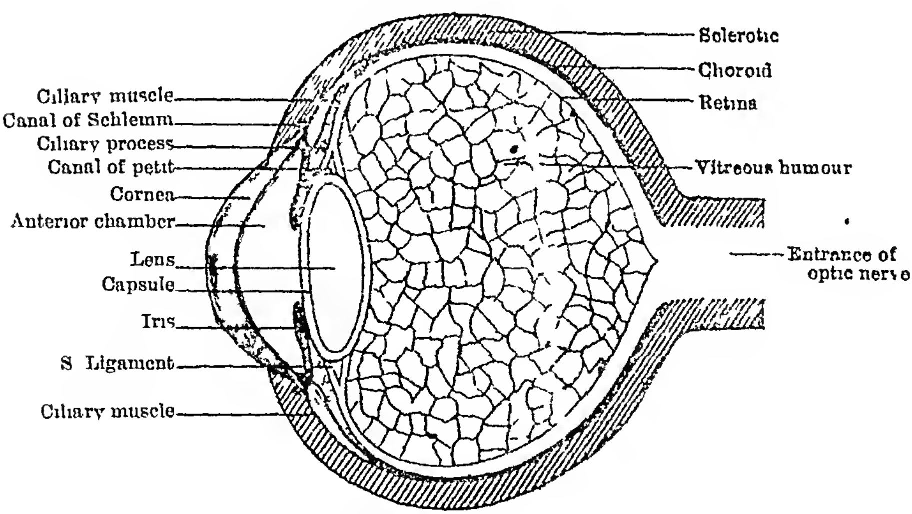


Fig 26

THE CORNEA

The cornea is transparent, circular outer coat forming one-sixth of the whole circumference of the eyeball It is blended with the anterior border of the sclerotic It is like a watch-glass by the edge of the groove into which it is received Its anterior surface is convex, projecting forward, and covered by the conjunctival epithelium Its posterior surface is concave, and bounds the chamber in which the aqueous humour is contained It is non-vascular nourished by the lymph

STRUCTURE—The cornea consists of five layers

1 ANTERIOR EPITHELIUM or conjunctival epithelium being continuous with conjunctiva It covers the front of the cornea proper It is squamous and stratified

2 ANTERIOR ELASTIC LAMINA —Modified basement membrane

3 PROPER CORNEAL SUBSTANCE —A compact form ot fibrous tissues which are in layers united together by cement substance Between the layers are flattened branching cell spaces which are occupied by two kinds of cells —

(1) CORNEAL CORPUSCLES—they possess many branching processes which anastomose with each other to form a cell network

(2) AMŒBOID CELLS OR WANDERING CELLS—they resemble white blood corpuscles and possess active amœboid movements

4 POSTERIOR ELASTIC LAMINA (membrane of descent) —It covers the proper cornea behind It is hard, elastic, when torn curls inwards towards the corneal tissue

5 POSTERIOR EPITHELIUM —It is endothelial lining of the aqueous humour forming a layer on the back of the posterior elastic lamina

THE SCLEROTIC.

The sclerotic coat, called from its white appearance "the white of the eye," forms five-sixths of a circle It is thicker behind than in front It is pierced behind by the *optic nerve,* and has a cribriform structure, as the bundles of nerve fibres do not pass through one large, but several small openings The sclerotic consists of the white fibrous tissue, intermingled with elastic fibres It overlaps the margin of the cornea Within the sclerotic, close to corneo-sclerotic junction in the sclerotic, is a lymph space called *Canal of Schlemm,* which communicates with the cavity of the aqueous It contains a few blood-vessels, and is provided with nerves

FUNCTION —It is the protecting coat of the eyeball

THE CHOROID

The choroid coat forms the largest portion of the middle coat of the eyeball It lies immediately beneath the sclerotic, and extends as far forwards as near to the cornea and ends in a series of plaits or folds—the " ciliary process " These folds fit into corresponding depression in the suspensory ligament of the lens It has a deep black colour, from the numerous pigment cells it contains, and is abundantly provided with blood-vessels and nerves

It is composed of the following layers —

(1) The stroma, or "lamina fusca," connects it with the sclerotic, and in it ramify the blood-vessels and nerves and pigments

(2) Venæ Vorticosæ-veins form the chief part of this coat.

3 TUNICA RUYSCHIANA—a very fine capillary plexus (chorio-capillarius)

4 LAMINA VITREA—very thin and transparent basement membrane

FUNCTION —The choroid is to absorb, by means of its pigments, those rays of light that pass through the retina,

and thus prevent their being thrown again upon the retina, so as to interfere with the distinctness of the images there formed Hence animals in which the choroid is destitute of pigment, and human albinoes are dazzled by daylight and see best in the twilight

CILIARY BODY

It consists of

(1) The ciliary process

(2) The ciliary muscle

THE CILIARY PROCESS is folding of choroid, or, as it is said above, it is ending of choroid These processes, about 80 in number separated from each other by furrows, which extend as far as the iris

THE CILIARY MUSCLE

It *arises at the* corneo-sclerotic junction and *inserted* into the choroid opposite the ciliary process

It is a fan-shaped muscle The fibres consist of radiating and circular The circular forms a ring round the insertion of the iris This ring muscle is called Muller's muscle

FUNCTION —The muscle draws the choroid and ciliary process forwards

THE IRIS

The iris is a circular, flattened diaphragm, situated behind the cornea, in front of the crystalline lens, and bathed by the aqueous humour It is attached by its circumference to the cornea, sclerotic, and ciliary processes (by the ligamentum pectinatum iridis) The iris gives the characteristic colour to the eye—blue, grey, brown, dark, hazel as the case may be It is perforated at its centre by a circular aperture, the *pupil,* the size of which is regulated by the contraction or relaxation of the muscular tissue of the iris This aperture, *the pupil,* transmits light

THE STRUCTURE

1 ANTERIOR SURFACE of the iris is covered by a layer of cells continuous with the endothelium of the aqueous humour

2 It has a stroma of connective tissue cells and fibres

3 The posterior surface is covered with a thick layer of cells filled with black pigment granules, the *uvea,* the variation in colour of the iris in different eyes depends upon the distribution and amount of the pigment in the uvea and stellate cells in dark-coloured eyes both are filled with dark pigments, while in light-coloured eyes the stellate cells of the stroma are either devoid of pigments or only faintly coloured The iris contains two sets of non-striped muscular fibres, namely —

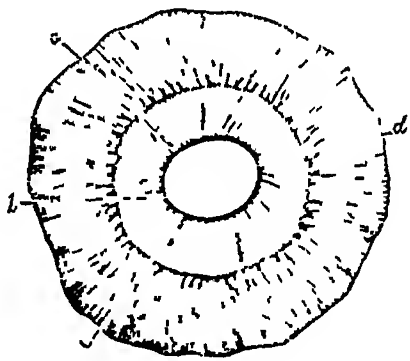


Fig 29

VIEW OF FRONT HALF OF THE EYEBALL SEEN FROM BEHIND

a, circular fibres, *b,* radiating fibres of the iris, *c,* ciliary processes, *d,* choroid

1 SPHINCTER PUPILLÆ which surrounds the aperture of the pupil The fibres are arranged circularly

FUNCTION —It acts sphincter to the pupil, by the contraction of which the size of the pupil is diminished

2 DILATOR PUPILLÆ—The fibres are arranged radiating from the pupillary to the ciliary border of the iris, acts as dilator of the pupil

The iris is very vascular, almost partaking of the character of an erectile structure

'The arteries are—the long posterior ciliary and the anterior ciliary The long make two arterial circles, major and minor

THE RETINA

The retina is peripheral end-organs of optic nerve It is a delicate nervous coat of the eye-ball, which lies immediately internal to the choroid, resting on the hyaloid membrane, and extends forwards almost to the outer edge of the ciliary processes, and ends in a finely indented border—the "*ora serrata*"

Its inner or anterior surface, concave forwards, is moulded on the vitreous body, and presents the following appearances —

1 Almost exactly in the antero-posterior axis of the eye-ball is a transversely oval *yellow spot* (*maculatutea*), about one-twentieth of an inch in its long diameter.

2 In the centre of this spot is a depression, the *fovea centralis*

3 The *optic disc*, or *white spot* about *one-eighth* inch to the inner side of yellow spot It is the entrance of the optic nerve or "blind spot" The central artery of the retina enters at the blind spot This part of the retina where the optic nerve enters is quite insensible to light, and is therefore called the blind spot

The retina may be regarded to a certain extent the sensitive plate of a photographic apparatus

The retina is highly complex in structure, and consists of nerve fibres and cells of peripheral end-organs, of connective tissue, and blood vessels, arranged in several layers.

THE LAYERS OF THE RETINA—

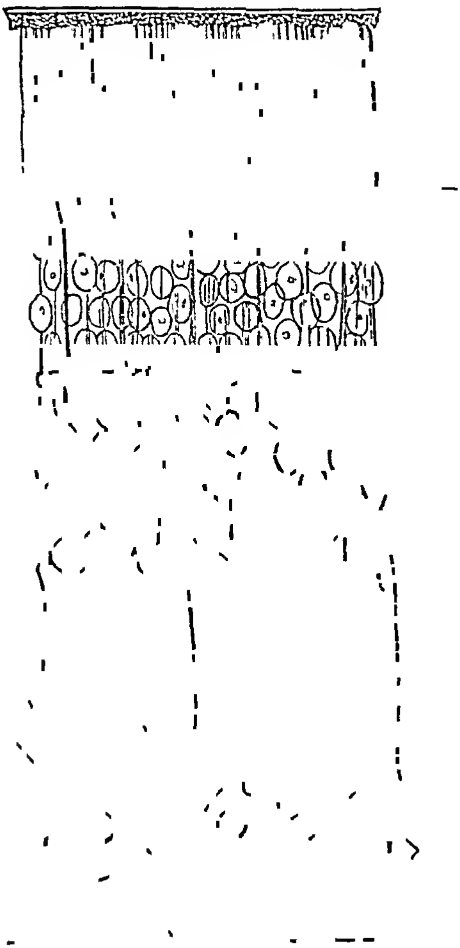


FIG 30—DIAGRAMMATIC SECTION OF THE HUMAN RETINA (AFTER SCHAFER)

1 Internal limiting membrane This is in contact with vitreous humour

2 Layer of nerve fibres—sheaths wanting, consist simply of axis cylinder

3 Layer of nerve cells This consists of nucleated multipolar cells

4 Inner molecular layer It consists of neuraglia traversed by fibrillar process

5 Inner nuclear layer This consists of Bipolar cells
6 Outer molecular layer.
7 Outer nuclear
8 External limiting membrane
9 Rods and cones
10 Hexagonal pigment cells (already mentioned under the choroid, *posterior layer of choroid*) Then choroid

The rods and cones are the peripheral end-organs of the optic nerve These are the visual cells The rods are more numerous than the cones, except at the yellow spot where the cones are numerous

THE CONES are shorter than the rods, they are tapering, and are interspersed at regular intervals between them, the apex of each cone is directed towards, but does not reach the plane of hexagonal pigment cells (posterior layer of choroid)

THE RODS —The outer end of each rod rests against the same layer (hexagonal pigment cells) It is purple colour The colouring matter is called "*visual purple*" This may be seen by keeping the eye in darkness It is soon bleached when the eye is exposed to light, while it is soon restored in darkness Each rod and cone is subdivided into an outer strongly refractile, and an inner feebly refractile, segment By the action of chloride of gold the outer segments both of the rods and cones exhibit a transverse striation, and ultimately break up into discs

CONNECTIVE TISSUE OF THE RETINA

Between the two limiting membranes lies the connective tissue of the retina It contains the perforating fibres or "*Fibres of Muller*" These fibres run in a radiate manner, and pass through the whole thickness of the retina, support and bind together the different layers

RETINAL EPITHELIUM —This consists of a single layer of epithelial cells containing pigments sending processes downwards, like the hair of a brush, between the

rods and cones These processes are influenced by the amount of light When the eye is exposed to light, the processes loaded with pigment penetrate downwards between the rods and cones as far as the outer limiting membrane

When the eye is in the dark, the pigment granules lie chiefly in the body of the cells, and in the processes near the cells (*Stirling*)

THE YELLOW SPOT

This spot shows some structural difference from the rest of the retina The yellow colour is due to yellow pigment deposited in the more anterior layers of the retina The yellow spot is the part of the retina most sensitive to light There are no rods, but the cones are more numerous, longer, and narrower All the other layers are much thinned at the fova, though at the margin they are thicker Blood vessels are almost wanting The outer granular and outer nuclear layers are well marked

THE BLOOD VESSELS OF THE RETINA —The retina is supplied with blood by the arteria centralis, which traversing the axis of the optic nerve reaches the retina at the optic disc In the retina it branches dichotomously in the nerve fibre layer, avoiding the yellow spot

OPTIC NERVE

The optic nerve pierces the sclerotic about one-eighth of an inch internal to the yellow spot, and its fibrous sheath blends with the sclerotic, and the nerve fibres pass through in several bundles, giving rise to a cribriform appearance

THE REFRACTING MEDIA OF THE EYE—

(1) Aqueous humour
(2) Crystalline lens and capsule
(3) Vitrous humour

THE AQUEOUS HUMOUR

The aqueous humour fills the anterior chamber of the eye-ball It resembles water, with a little solid matter,

chiefly chloride of sodium This fluid secretes pretty rapidly by the epithelial cells of iris and ciliary processes, when evacuated through a wound in the cornea, it is rapidly refilled

? THE ANTERIOR CHAMBER is the space situated between the iris and cornea

THE POSTERIOR CHAMBER lies behind the iris containing vitreous humour which is jelly-like connective tissue

THE CRYSTALLINE LENS

The crystalline lens lies in a thick strong capsule It is situated behind the iris and the pupil, and in front of the vitreous body It is transparent *bi-convex* lens, its posterior surface is more convex than the anterior with its circumference rounded It is composed of concentric laminæ, but these are not continuous all round The outer portion is soft, the central part is harder and denser, named nucleus of the lens There are faint white lines, three in number, diverging from the centre

In the hardened lens, concentric laminæ may be detached like the coats of an onion

APPEARANCE OF LENS AT DIFFERENT AGE

In the fœtus, it is almost spherical, vascular ("hyaloid artery") and reddish in tint, and soft, rounded

2 IN THE ADULT the posterior surface is more convex, it is non-vascular, colourless, transparent, and firmer

3 IN OLD AGE, it is flattened on both surfaces, yellowish in colour, tougher and denser

THE VITREOUS HUMOUR—

The vitreous body is much the largest of the refracting media, and occupies the largest part of the interior of the eye-ball inside the retina It consists of the layer of mucous tissue containing mucin, with lymph It is translucent as glass, like jelly, and when punctured a watery fluid drains

out Anteriorly it is hollowed out to receive the posterior convexity of the lens, and the retina is moulded on it The central part is fluid, and the part next to the retina is in distinct layers called *hyaloid membrane* A membrane springs from the vitreous body, opposite the ora serrata passes forward and become attached to the anterior surface of the capsule of the lens It is called suspensory ligament of the lens or "Zonule of Zinn," round the edge of the lens the canal left is called the *Canal of Petit*

LYMPHATICS OF THE EYE—

The lymphatics of the eye consist of two sets, viz —

1 POSTERIOR SYSTEM —The coverings of the optic nerve are like those of the brain

(1) Dura mater

(2) Prolongation of the parietal and visceral layers of the arachnoid, with arachnoid and sub-arachnoid spaces.

(3) Pia mater

There are thus two lymph spaces round the optic nerve, continuous with those of the brain They open into the perichoroidal lymph space, and also communicate with Tenon's space

INTRAOCULAR TENSION

The cavity of the eye-ball is filled with watery fluid which is subjected to the pressure This depends upon the blood-pressure within the arteries of the retina

The pressure is determined by pressing upon the eye-ball to ascertain whether it is tense, soft and compressible The pressure on the sclerotic of a healthy eye will cause dimpling, as the lymph is forced through the lymph spaces When the tension is very much increased, the condition is termed *glaucoma*

SIGNS OF GLAUCOMA —

1 Pressure fails to dimple the sclerotic

2 Eye-ball hard, increased tension

3. Pulsation may be seen in the veins of the retina

4 Halos or rainbows round candle or any other light, caused by œdema of cornea from intraocular fluids

NERVES OF THE EYE

1 OPTIC NERVE —Nerve of special sense

2 LONG OR SENSORY ROOT —From the nasal branch of the fifth, nerve of common sensation

3 SHORT OR MOTOR ROOT —From the third, motor to the ciliary muscle, and circular fibres of iris

4 SYMPATHETIC —Motor to blood-vessels, and radiating fibres of iris

THE SUMMARY OF OPTICAL MECHANISM FOR PRODUCTION OF IMAGES

The eye-ball may be compared to a

CAMERA OBSCURA —In a camera images of external object are thrown upon a ground glass screen at the back of a box, the interior of which is blackened The sclerotic forms the wall of the box The choroid represents the black lining for absorbing the surplus rays of light The cornea, aqueous humour, lens, and vitreous humour, are the refractive media which like the glass lens of the camera obscura, bring the rays of light to a focus The layer of rods and cones of retina is represented as ground glass screen on which the optical picture is thrown It must be kept in mind that the place of entrance of the optic nerve is insensible to light, and that the most sensitive part of the retina is the yellow spot It is clear that the rods and cones are the structure in the retina which are stimulated by the light, not the optic nerve fibres The iris is the diaphragm which, by opening or closing the pupil, admits or cuts off the rays of light. The ciliary muscles represents the adjusting screw of the camera, through its attachment to the ciliary processes and their relation to the suspensory ligament of the lens, it is able to act upon the lens and modify the curvature of its anterior surface, for when the eye is to be

accommodated to the vision of near objects, the anterior surface of the lens becomes more convex than when distant objects are being examined

THE SENSE OF VISION

The sense of vision is excited by the influence of light on the retina By the excitation of the retina, a molecular change is induced in the optic nerve fibres, which is conveyed by these to the brain (centre of sight) resulting into a sensation of light or colour One of the first conditions necessary to produce vision is the formation of an image on the retina The eye is being compared with a photographic camera, just like this, refractive structures must be placed in front of the retina causing the luminous rays to be bent so as to bring them to a focus on the retina, and thus production of an image

OPTICAL ARRANGEMENTS OF THE EYE

Unlike the camera which possesses a single lens, however, the eye has four lenses

THE LENSES OF THE EYE ARE—

(1) Cornea
(2) Aqueous humour.
(3) Crystalline lens
(4) Vitreous humour

THE REFRACTING SURFACES ARE—

(1) Anterior surface of the cornea
(2) Anterior surface of the lens
(3) Anterior surface of the vitreous humour

REFRACTION OF THE EYE

When light traverses any homogenous transparent medium, such as the air, it passes on in a straight course, but if it meet with any other transparent body of a different density, part of it is reflected or returned to the first medium, whilst the remainder is propagated through the second medium in a different direction.

The eye is a nearly spherical organ, formed of transparent parts Before a ray of light can reach the retina, it must pass through these transparent and refractive surfaces. The ray must therefore traverse the cornea, aqueous humour, lens, vitreous humour These are refractive media bounded by curved surfaces, which are approximately spherical Owing to this circumstance, they possess the property of focussing rays which pass into them, or, in other words, of collecting them towards a point The parallel rays passing through denser medium become bent towards a point which is called their focus.

THE FORMATION OF RETINAL IMAGE

In distinct vision the inverted image is formed on retina, the retinal image is composed of innumerable foci of the object

THE CONDITIONS NECESSARY FOR CLEAR SIGHT ARE—

1 The image must be clearly focussed on the retina, *i e*, the retina must lie exactly at the focus of the rays which proceed from the object looked at

2 The image must be formed at the centre of the yellow spot

3 The cornea, lens, and vitreous must be clear

4 The illumination must be sufficient

INFLUENCE OF THE PUPIL —The larger the pupil the worse is the sight —(*Nettleship*)

REDUCED EYE

One without the lens the lens is not essential for sight, the anterior surface of the cornea would cause sufficient refraction, only one could see distant objects, and the condition is termed *aphakia* The degree of hypermetropia varies according to the state of previous refraction

ACCOMMODATION OR THE MECHANISM OF ADJUSTMENT FOR DIFFERENT DISTANCES

The eye by virtue of its own muscular contraction has the

power to accommodate itself to vision at different distances, hence objects placed at various distances from the eye can be seen with almost equal distinctness, not at the same time, but one after the other It is this special provision, by which the eye is enabled to adapt itself for varying focal distances, that is called "accommodation"

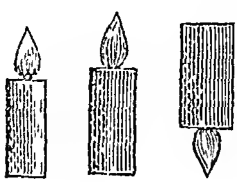
This is accomplished by altering the curvature of the crystalline lens It is mainly the anterior surface whose curvature alters For distant objects the lens becomes flatter, for near objects more convex

N B—To ascertain measurement of accommodation by adding a convex meniscus (a lens which is concave on one side and convex on the other) to the lens, the refractive strength of which meniscus gives the measure of accommodation, so that it is spoken 2, 3, 4, 10 or 14 diaptres of accommodation

PROOF—That the anterior surface of the lens undergoes into change

SANSON'S IMAGES—

To perform the experiment one must be in a darkened room with a candle Hold the candle a little to one side of another person's eye, and then look into the eye from the opposite side Three images of the candle are seen in the eye This is known as Sanson's images—two are *erect* and one is *inverted* representing the change occurring in the refractive surface The middle one undergoes most change as the individual looks at a near or a distant object



1 2 3

These three images represent thus —

1 First image is bright *erect* from the anterior surface of cornea

2. The second or middle is also *erect* but *dim* from the anterior surface of the crystalline lens

3 The third or last is *inverted*, very *dim*, from the posterior surface of the lens, or perhaps the concave surface of the vitreous humour to which the convex surface of the lens is adapted

Suppose the three images to be in the position shown in the figure for distant vision, it will be found that the middle image (2) moves towards the first (1), on looking at a near object The change is due to an alteration of the curvature of the lens This proves when the eye is accommodated for near object, the anterior surface (or middle) becomes more convex, and that the cornea and posterior surface of lens don't change their surface

There are two kinds of accommodation, viz —

1 NEGATIVE—or distant—*i e*, a distant object is one 18 feet or more distant from the eye, the rays from such an object are parallel

2 POSITIVE—or near, *i e*, a near object is one nearer than 18 feet, the rays from such an object are divergent

✓ MECHANISM FOR POSITIVE ACCOMMODATION OR NEAR

1 The ciliary muscle contracts

2. The choroid and ciliary processes are drawn forwards and inwards by the action of radiating part of ciliary muscle

3 This relaxes the suspensory ligament

4 The anterior surface of lens bulges forwards by virtue of its own elasticity, and thus increases its convexity

5 The pupil becomes smaller to diminish spherical aberration

MECHANISM FOR NEGATIVE ACCOMMODATION OR DISTANT

It is due to the elasticity of the suspensory ligament When the ciliary muscle is relaxed, the ligament again becomes tense and flattens the anterior surface of the lens and the pupil becomes larger

N B —The fatigue is produced in the eye by looking for long time the near object The cause is that ciliary muscle is thrown into contraction for longer than required, thus produced fatigue in the eye It is overcome by looking at distant object

THE NEAR POINT IN THE ACCOMMODATION is the point where the object looked at is most distinct Every eye must have limit in the power of accommodation, *i e*, if a book be brought nearer and nearer to the eye the type becomes indistinct The near point—

In the adult, about 10 inches.
In the child, about 3 inches

The reason why the distance increases as age advances is that the lens becomes more flattened

The Scheiner's experiment determines and measures the near point

EXPERIMENT—

Make two small holes in a cardboard with a pin, these holes should be very close to each other The cardboard is held close in front of the eye, and a needle looked through the holes At a moderate distance it can be clearly focussed, but when brought nearer, beyond a certain point, the needle appears double or blurred The point where the needle ceases to appear single is the near point The distance from the eye is measured

ERRORS OF REFRACTION

THE NORMAL OR EMMETROPIC EYE is given name to that eye that any number of parallel rays coming from a great distance is focussed on the retina The near point

being about 10 inches distant from the eye, the far point

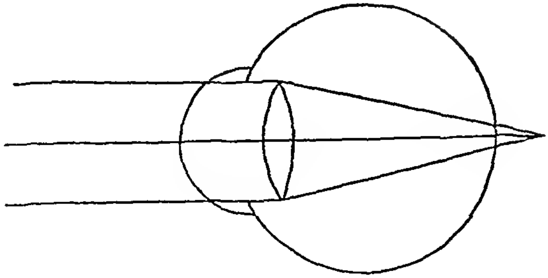


Fig 31 Normal

18 feet or over The length of the eye must be in normal condition

1 MYOPIA OR SHORT-SIGHTED

It is short-sight one cannot see distant objects clearly. The near and far points are both nearer to the eye The parallel rays are brought to focus in front of the retina, and these rays decussate within the vitreous humour

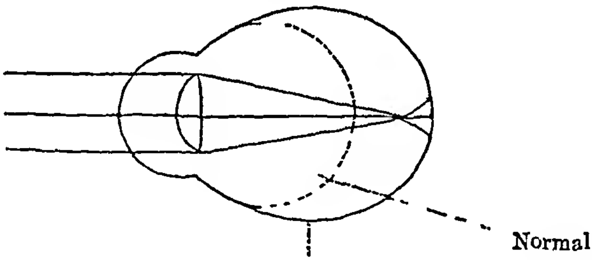


Fig 32 Myopic

STRUCTURAL CHANGE —The antero-posterior axis of the eyeball is *lengthened,* and there is an increase convexity of the lens

CAUSES —It is very rarely congenital The elongation of the globe of the eye comes on gradually during the growing period of life, and especially between the ages of ten and twenty It is frequently due to hereditary, and reading or writing in dim flickering light

SYMP —Patient complains he cannot see distant objects clearly, he can see distinctly when things are held very

close He sees distant objects with half-closed lids and frowning expression These lessen the indistinctness of objects beyond the far point

This anomaly of the refraction is corrected by allowing the patient to wear *concave* (diverging) lenses The concave glass makes the parallel rays divergent, so that they can be brought to focus in front of the retina.

LONG-SIGHTEDNESS—

There are two forms—

(1) HYPERMETROPIA —The naturally long-sighted eye, due to an error of refraction

(2) PRESBYOPIA —Long sight of old age, due to an error of accommodation, *e g* , a person cannot see near objects

HYPERMETROPIA—

It is "long-sight" and exactly the reverse of myopia The "near point" is removed from the eye more than ten inches, but the "far point" is also removed The parallel rays are brought to focus behind the retina, hence a person always holds objects far off from the eye The power of accommodation is good and the trouble is due to a natural structural defect of the eye—an error of refraction

STRUCTURAL CHANGE—

The antero-posterior axis of the eye *is too short* and the lens is too flat.

CAUSE.—Imperfect development of eye-ball in all directions

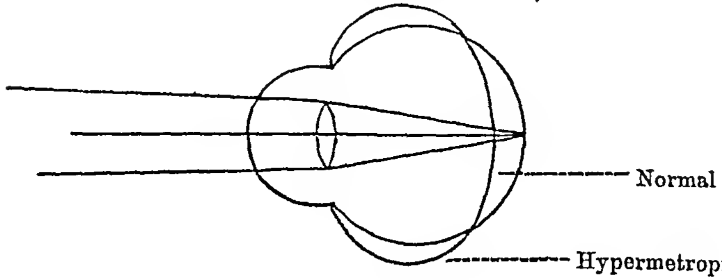


Fig 33

ATROPINE TEST.

Under the influence of atropine the hypermetropic eye can see nothing clearly, either distant or near, because the ciliary muscle is required to bring even parallel rays to a focus.

2 PRESBYOPIA or long-sight of old age—

In this case near point of vision is removed to more than ten inches, but the far point is unaffected The old people cannot see the near object distinctly without holding it at a considerable distance from the eye (This trouble is due to a defect in the mechanism of accommodation) The defect usually begins about forty years of age

STRUCTURAL CHANGE—

1 The lens becomes *flatter*, *denser* and *less elastic*, so the lens does not become convex when suspensory ligament is relaxed

2 The weakness of ciliary muscle

CORRECTION OF LONG-SIGHTEDNESS

Both forms of "long-sight" are corrected by using *convex* (convergent) glasses which render the rays of light more convergent, such glasses are specially needed for near objects, as in reading, &c

ASTIGMATISM.

The defect depends upon a want of symmetry in the refractive power of the different meridians of the eye When the curvature of the refractive surfaces of the eye is unequally great in its different meridians, say, for example, more convex or concave in one meridian than in another, the rays of light cannot be focussed in one point, there will be two linear foci Commonly the fault is in the vertical meridian, caused in the majority of cases by unequal curvature of cornea Thus vertical and horizontal (+) lines crossing each other drawn on white paper. These

lines cannot be focussed at once, one set stands out clearly, while the other is blurred This defect is present to a slight degree in all eyes

THERE ARE TWO MAIN VARIETIES, viz —

1 Regular due to fault of cornea

(a) SIMPLE —Normal in one meridian, hypermetropic or myopic in the other

(b) MIXED —Hypermetropic in one meridian, myopic in the other

(c) COMPOUND —Hypermetropic or myopic in both meridians, but defect in one meridian greater than in that of the other

Patient complains of seeing imperfectly both far and near objects

2 IRREGULAR—due to the fault of lens Here the image is seen not as a circle but as a radiate figure

CORRECTION OF THE DEFECT

The defect is corrected by the use of cylindrical glass (curved only in one direction), concave or convex in the meridian that requires correction

TEST —If an astigmatic eye looks at a number of lines drawn in different directions, some will be seen more clearly than others

Or a clock face with Roman figures may be used as test

SPHERICAL ABERRATION

One cannot see every point of an object at once with equal clearness The focus for the middle is not the same as that for the ends, when the ends are seen clearly, the middle part is blurred, and *vice versâ*

CAUSE—

The refraction of the rays passing through the circumference of an object is greater than that of the rays traversing its central part, they therefore cannot all come to a focus at one point and hence the blurring.

The rays of light impinge most obliquely are brought further forward than direct rays, hence central rays, of an object reflected distinctly, whilst peripheral rays are not refracted distinctly

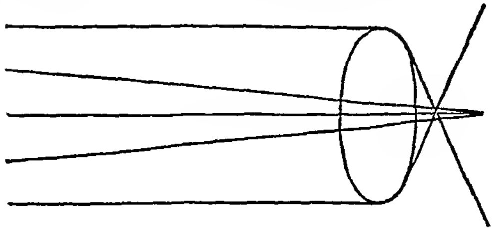


Fig 34

It is overcome in the eye by means of the iris, which forms a contractile diaphragm, altering its size according to the intensity of the light Further, the posterior surface of the iris is pigmented to prevent rays passing through its substance in any part except the aperture of the pupil The pigment of the choroid and ciliary processes also absorb light, and prevent it being reflected to the retina

SNELLEN'S TYPE TEST FOR VISUAL OCUITY.

These consist of a number of letters of the alphabets or other figures painted black on a white background A series of such letters or figures arranged as lines, the letters in each line being the same size, while there is a difference in the size of those in consecutive lines, constitute the set of test types Above each line is placed a number indicating in feet or metre the distance at which the letters should be read The number of lines with letters usually employed is seven The letters have no special relation to one another, they do not combine to form words, and thus do not easily become familiar The visual acuity should be tested, first without and then with the aid of suitable glasses

DIOPTRE OR "DIOPTRIC"—(διόπτομαι = to look through) The term is used to express refraction of light

THE LENS which can bend parallel rays to a focus at a distance of metre from its centre is taken as the unit of lens measurement, and is called a lens of one dioptre (D) (Dioptre = 1 metre = 39 inches) The lenses differ by equal refractive intervals. For convenience the convex lens

is expressed by the sign plus (+) and the concave lens is expressed by the sign minus (—)

IRIS

FUNCTION—

1 It regulates the amount of light reaching the retina, if the light be intense, it becomes smaller

2. The iris acts as a diaphragm by cutting off the marginal rays, if they entered the eye, would cause spherical aberration, and thus lessens the spherical aberration. —

THE CHANGES IN THE PUPIL

THE PUPIL CONTRACTS—

1 When light falls on the retina—the brighter the light the greater the contraction

2 In accommodation for near object, *i e*, the pupil becomes smaller

3 When the eye-ball is turned inwards

4 By the action of certain drugs, as opium, calabar bean

THE PUPIL DILATES—

1 In passing from bright to dim light

2 When the eye accommodates for distant objects

3 By the action of certain drugs, as atropine

ARGYLE ROBERTSON PUPIL —In this condition pupil does not contract to light It is one of the signs of loco motor atoxia

NERVES TO THE MUSCLES OF IRIS

1 SYMPATHETIC supplies to the dilator pupillæ. Its centre is always in action and is automatic, its position is in the floor of the front part of the aqueduct of sylvius

2 THE THIRD NERVE supplies to the sphincter pupillæ Its centre is reflex, and is placed in the corpora quadrigemina

THE EXCITABILITY OF THE RETINA.

(The retina is not equally excitable in all its parts At the entrance of the optic nerve there is no sensibility to light Hence this part of the retina is called "blind spot" or optic disc This spot consists entirely of optic nerve-fibres and contains no rods and cones, and therefore these fibres are insensible to light)

This spot can be demonstrated by—

MARIOTT'S EXPERIMENT—

(Close left eye and fix right eye on cross)

Fix one eye on the cross and close the other, and then move the dot sideways over the paper towards the outer side of the field of vision The dot is first seen, then it disappears for some time (because focussed on the "blind spot,") and is then seen again as the paper is slowly moved in the direction indicated

THE YELLOW SPOT —This spot is situated in the centre of the retina in the most sensitive part of the retina to light If we wish to see any object very clearly, we always move the eyes to make the image to fall on the yellow spot Thus, if we fix the eye on a word in the centre of this line, it is distinctly and sharply seen, but the words towards each end of the line are vague If we wish to see each word distinctly, we "run the eye" along the line, that is we bring each successive word on the yellow spot

It is believed that fovea centralis which is situated in the centre of the spot consisting entirely of cones is the area of most acute sensibility

DEMONSTRATION FOR YELLOW SPOT—CLARK MAXWELL'S METHOD

Look into a solution of chrome alum On looking into this solution a reddish spot is seen, because the yellow pigment of the macula lutea absorbs the greenish-blue rays, but the red pass through to Jacob's membrane

PURKINGE'S FIGURES.

In order to perform this experiment, go into a dark room having its walls covered with grey paper, and move a candle to and fro at the side of and close to one eye, while the eyes look steadily forwards into the darkness, remarkable branching figures, like roots of trees, are then seen floating before the eyes, like dark lines on a reddish ground These are Purkinge's figures and the shadows of the retinal blood-vessels The light entering the eye obliquely throws the shadows of the retinal blood-vessels on the seeing part of the retina

THE RODS AND CONES

These figures signify that light-perceiving elements of the retina must be behind those vessels, and therefore not in the fibres of the optic nerve, but some of the external layers of the retina, probably the *rods* and *cones*.

DURATION OF A RETINAL IMPRESSION

The duration of retinal stimulation is exceedingly short. It has been ascertained that an impression lasts on the retina from one-fiftieth to one-thirtieth of a second It is proved by means of a white spot on a revolving disc Turn slowly, the spot can be seen quite well Turn rapidly, only a grey circle is seen

AFTER-IMAGES —They may be—

1 POSITIVE —Look at a window for a second, and then close the eyes, if of the same colour as before, then it is a positive after-image

2 NEGATIVE —In this case the after-image is changed in colour, *e g*, look at the sun and then close the eyes, a black image is seen

VISUAL PURPLE—

It is a reddish-purple tint, seen in the outer segments of the rods The colour is due to pigments which are in a state of solution.

EFFECT OF LIGHT ON VISUAL PURPLE

Light bleaches it, it is quickly restored in the dark by the hexagonal pigment cells Throw a bright light in the form of a cross on the retina of an animal, and then rapidly kill and examine A bleached cross is seen in the *visual* purple of the outer segments of the rods

IRRADIATION is the name given to that phenomena where we form a false estimate of visual impression owing to imperfect accommodation Let us have two squares for the examination of this phenomena If we look at the white square in the black field appears to be larger than the black square in the white field, although both are of exactly the same size When the accommodation is quite accurate, the phenomenon of irradiation is not present

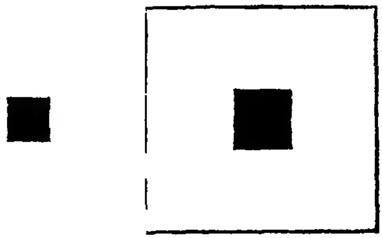


Fig 35

SENSATION OF COLOUR

Colour is a sensation, and not a property of light Only those rays of light which have a medium wave length stimulate the retina Thus we have a sensation of red when a certain number of waves of light impinge on the retina in a unit of time, and with about twice the number of waves in the same time the sensation will not be of red but of violet

SIMPLE COLOURS —When a spectrum is examined we see a series of colour, thus—red, orange, yellow, green, blue and violet

MIXED COLOURS—Are those which produce a sensation of two or more rays of simple colour in the same spot of retina simultaneously or rapidly alternating

THE COMPLEMENTARY COLOURS —Any two simple colours mixed together give rise to the sensation WHITE

Thus—Red + greenish blue
Orange + cyonic blue
Greenish yellow + violet
} =White

The following table shows the compound colours produced by mixing other colours At the top of the vertical and horizontal columns are placed the simple colour —

(*Helmholtz*)

	Violet	Indigo blue	Cyonic blue	Greenish blue	Green	Yellowish green	Yellow
Red	Purple	Dark rose	White rose	White	Whitish yellow	Golden yellow	Orange
Orange	Dark rose	White rose	White	Whitish yellow	Yellow	Yellow	
Yellow	White rose	White	Whitish green	Whitish green	Yellowish green		
Yellowish green	White	Green	Green	Green			
Green	Blue	Water blue	Greenish blue				
Greenish blue	Water blue	Water blue					
Cyonic blue	Indigo blue						

COLOUR-BLINDNESS is the defect in the visual field of some individuals who are unable to distinguish certain colours There are the following kinds of colour-blindness —

(1) Red-blindness.
(2) Green-blindness
(3) Violet-blindness

In red, for example, the special nerve endings for red rays are wanting, and hence white seems a bluish-green, and a red object dark green

Santonin poisoning causes violet blindness, as it paralyses the violet nerve endings for the time being

TEST FOR COLOUR-BLINDNESS

"The best test used is small skeins of coloured wool of different colours—thus, red, orange, yellow, greenish-yellow, green, greenish-blue, blue, violet, purple, rose, brown, grey Select one skein, and place it in front of person tested and put it aside, and then ask him to seek out those skeins which he supposes are nearest to it in colour" (*Stirling*)

OPHTHALMOSCOPIC EXAMINATION OF THE FUNDUS

THE METHOD OF CONDUCTING AN OPHTHALMOSCOPIC EXAMINATION —The patient should be in a darkened room The light used, whether gas or lamp, should have broad flame, and should be placed on the same level as the eye that is to be examined and on the same side of the head the observer sits facing the patient The light should be placed close to the patient's head and a little behind, so that the only light that reaches the eye shall be from the ophthalmoscope Taking the concave mirror in the hand, and looking through the central hole, we throw the light on to the eye, and light up the fundus, making the pupil appear *red* There are two methods of examining the fundus—(1) *direct*, (2) *indirect*

(1) THE DIRECT METHOD —This method of examining the fundus only allows a small portion to be seen at one time, but this portion is considerably enlarged First the observer must relax his accommodation The patient must also be made to relax his accommodation, which can be done by directing him to look at some object The light is quite close to the patient's head and slightly behind, and the observer sits on the same side of the patient as the eye he

wishes to examine, using right eye for the right, and left for the left The small upper mirror is used The light should then be focussed on the eye with the ophthalmoscope approaching within 1 or 2 inches When light is reflected into the patient's eye, an *erect image* of a small portion of the fundus is obtained

(2) THE INDIRECT METHOD —This method consists of that the observer holds the opthalmoscope in one hand and reflects light from larger mirror into the eye of the patient from a distance of 18 inches In his other hand he supports a convex lens of 3 inches' focus at its focal distance from the patient's eye, resting his little finger on the patient's brow By means of this lens the beam of light reflected from the mirror is concentrated, so that the whole of it enters the patient's pupil The *inverted* image of fundus is obtained

The light should be so placed that the patient's face is in a shadow The observer should hold the mirror in his right hand when using his right eye, and in his left when using his left eye The advantage of this method is that it gives an extensive view of the fundus.

THE OPHTHALMOSCOPIC APPEARANCE OF THE NORMAL FUNDUS

The red colour of the fundus is chiefly due to the blood-vessels of the choroid The fundus varies in colour in different people In some the colour is a bright yellowish red, in others a dark or brown red, and these differences are due to the varying quantity of pigment present Dark people have, as a rule, a dark fundus The examination of the parts of the fundus in the following order should be made —

THE OPTIC DISC —The optic disc should be first sought for In order to bring this disc in view, ask the patient to turn his eye inwards Make out the following condition —

SIZE —Size depends on refractive condition.

SHAPE.—Circular

COLOUR —Roseate

EDGE —Usually well defined It exhibits a fine white circle of sclerotic, surrounded by a dark ring "choroidal ring"

THE SURFACE OF THE DISC —The centre of the disc is lightest in colour, and presents depression called "physiological cup"

THE MACULÂ —The macula will be found two discs' breadth outer side of the disc In order to see the macula direct the patient to look towards the mirror It is seen in posterior pole of pigmentation in the retina The macula is oval, and is surrounded by silvery halo of reflected light It often presents a bright yellowish point at the centre—the *fovea centralis*

THE RETINAL VESSELS —The retinal vessels pierce the disc at the cup The arteries are lighter in colour than the veins The central artery and vein first divide into *two main branches,* one going to the upper and the other to the lower portion of the fundus. These again divide

Pulsation of the arteries in normal condition is not seen, but pulsation of veins close to its termination at the disc is seen. Pulsation of the arteries has been seen in glaucoma

THE MOVEMENTS OF THE EYE

The globe of the eye has a *centre of rotation* which is not exactly in the centre of visual axis, but it is situated a little behind the visual axis The axis of rotation are three—

(1) THE ANTERO-POSTERIOR or visual axis —This axis unites a line drawn from vertex of the cornea to the fovea centralis

(2) THE HORIZONTAL OR TRANSVERSE is the straight line connecting centre of rotation in both eyes

(3) VERTICAL—a line passes vertically through the centre of rotation.

THE EYE-BALL

The movement of the eye-ball is caused by the action of group of muscles They are in number six. If individual muscles are paralysed, the position of visual axis is disturbed, and thus *squinting* results The following table gives the movement brought about by the muscles —

Inwards	Internal rectus.
Outwards	External rectus
Upwards	Superior rectus Inferior oblique
Downwards	Inferior rectus Superior oblique.
Inwards and upwards	Internal rectus Superior rectus Inferior oblique
Inwards and downwards	Internal rectus Inferior rectus Superior oblique
Outwards and upwards	External rectus Superior rectus Inferior oblique
Outwards and downwards	External rectus Inferior rectus Superior oblique.

SIMULTANEOUS MOVEMENT OF THE BOTH EYE-BALLS

Both eyes are always moved simultaneously The movement is brought about by the action of muscles presided by

the centre of the co-ordinating movement of the eye-ball The centre for co-ordinating movement is placed in the *corpora quadrigemina*

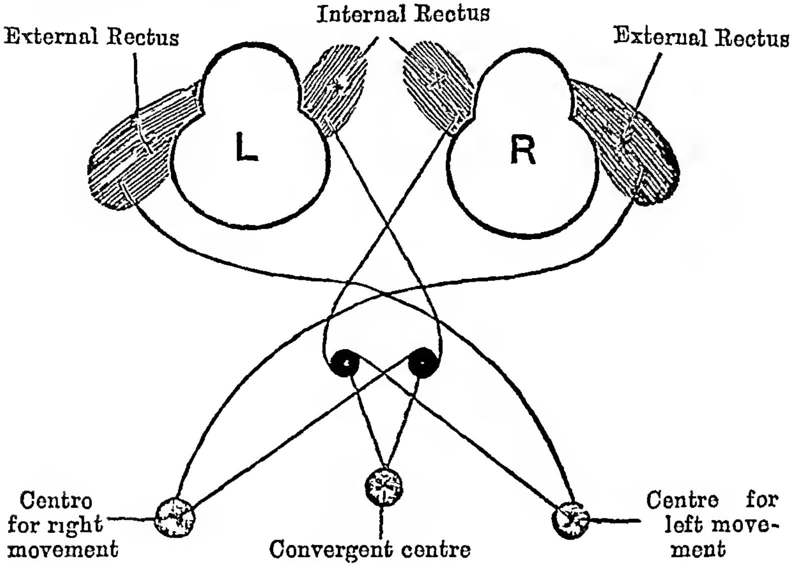


Fig 36

THE SCHEME SHOWS THE SIMULTANEOUS MOVEMENT OF THE BOTH EYE BALLS

There is convergent centre This centre for convergence is thrown into action to bring both internal recti into contraction in order to converge the eye upon the vision of near object There are decussession of fibres so as right presides over the left internal rectus Similarly left presides over the right rectus

There are centres for the lateral movement of both eyes on each side

The impulse starts from the right centre for lateral movement, and it passes to the same side as well as to the other side The result of this is that co-ordinating movement is brought about, *i e*, both eyes are moved at the same time For instance, if right lateral centre is stimulated, the left external rectus and the right internal rectus will be thrown into action, so that the left eye will move outwards and whilst the right eye will at the same time move inwards

PROTECTIVE ORGANS OF THE EYE

The eyelids are two movable folds, placed in front of the eye, protecting it from injury by their closure The eye is opened by the levator palpebræ (third nerve) and closed by the orbicularis (seventh nerve)

STRUCTURE—

(1) Skin.

(2) Orbicul

(3) Loose connective tissue

(4) Tendon of levator palpobræ

(5) Tarsal cartilage

(6) Meibomian glands

(7) Conjunctiva

MEIBOMIAN GLANDS—are situated upon the inner surface of the eyelids, between the tarsal plates and conjunctiva Their ducts open on the margin of the lids by minute openings These glands are sebaceous glands

CONJUNCTIVA —It is the mucous membrane of the eye It lines the inner surface of the eyelids and over forepart of the sclerotic and cornea.

The palpebral portion is highly vascular and covered with papillæ, which is called granular lids in the disease

CONNECTION

1 It becomes continuous with the ducts of meibomian glands

2 It is continuous through the lachrymal canal with the membrane of lachrymal sac and nasal duct

3 It becomes thin upon the schlerotic

4 It is continued over the cornea as its anterior epithelium

LACHRYMAL APPARATUS

The lachrymal apparatus consists of—

(1) Lachrymal gland and its ducts

(2) Puncta lachrymalia, the opening of the

(3) Canaliculi, which leads into
(4) Lachrymal sac, from which the
(5) Nasal duct descends to open into the inferior meatus of the nose

VOICE AND SPEECH

VOICE is produced by the vibration of the vocal cords (two bands of elastic tissue) situated in the larynx

SPEECH is the production of sound intended to express ideas. The difference between voice and speech is—

Voice can be produced in the larynx alone Speech requires mouth and lips as well as the larynx

THE APPARATUS FOR PRODUCTION OF VOICE AND SPEECH ARE—

(1) Bellows, viz, lungs and chest
(2) Vibrating membrane, viz, the vocal cords
(3) Chambers for resonance and articulation—chest, pharynx, mouth, and nose

The larynx is the organ of voice It opens below into the trachea and above into cavity of mouth It consists of cartilages and ligaments These cartilages are movable on each other by the action of various muscles, which thus regulate the tension of the vocal cords The trachea conveys the blast of air from the lungs during expiration to the sounding body contained in the larynx The aperture made by two margins of vocal cord is forced to be opened for the escape of air Thus the membrane is thrown into vibration

THE CARTILAGES OF THE LARYNX.

They are three paired, and three single—

1 SINGLE—

(1) CRICOID—resembles a signet ring

(2) THYROID—It consists of two lateral plates united in front at an angle, and covered by a bursa The posterior border is prolonged into cornea

(3) EPIGLOTTIS.—It is shaped like a leaf, and situated behind the tongue, and in front of the superior of the larynx. It plays a special part during the act of deglutition. The epiglottis is drawn down by the action of aryteno-epiglottiden, and at the same time the larynx is drawn up to meet the epiglottis. The glottis is also closed during deglutition, so that there is a double safeguard against the entrance of food into the larynx.

2. PAIRED—

(1) ARYTENOID.—This pair of cartilage resembles pyramid, having three surfaces, a base, and apex. The base is seated on the cricoid, its anterior angle giving attachment to the true vocal cords, and its external angle to the crico-arytenoideus posticus and lateralis. The posterior surface gives attachment to the arytenoids, the anterior to the false vocal cords and thyro-arytenoids.

(2) Cornicula laryngis (Santorini).

(3) Cuneiform cartilages (Wrisberg).

THE LIGAMENTS OF THE LARYNX

1. EXTRINSIC—

(1) Thyro-hyoid membrane.

(2) Lateral thyro-hyoid ligaments.

2. INTRINSIC—

(1) Crico-thyroid membrane—

(a) Mesial part.

(b) Lateral parts.

(2) Superior thyro-arytenoid ligaments.

THE TRUE VOCAL CORDS

They are two bands of yellow elastic tissue covered with mucous membrane, attached in front to the angle between the alæ of the thyroid, and behind to the anterior tubercles at the base of the arytenoids. They are formed by

the upper free edge of the lateral parts of the crico-thyroid membrane, and their free edges are directed upwards They are called "inferior thyro-arytenoid ligaments"

THE FALSE VOCAL CORDS.

A few fibrous fasiculi in the mucous membrane, forming projecting folds, and situated above the true cords They are also called the "superior thyro-arytenoid ligaments"

THE VENTRICLES OF THE LARYNX

Narrow openings (one on each side) situated between the false and the true vocal cords termed ventricle of Morgogni They communicate with the laryngeal sac and a pouch between the true and false cords The ventricles permit a free vibration of the true vocal cords

THE INTRINSIC MUSCLES OF THE LARYNX.

1 CRICO-ARYTENOIDEUS POSTICUS—

ARISES—from the posterior part of the cricoid cartilage

INSERTED—into the posterior external tubercle of the arytenoid

ACTION.—It opens the glottis by rotating the arytenoids round a vertical axis

2 CRICO-ARYTENOIDEUS LATERALIS

ARISES—from upper border of the lateral part of the cricoid cartilage.

INSERTED—into the posterior external tubercle of the arytenoid

ACTION—It closes the glottis

3 CRICO-THYROID

ARISES—from the side of the cricoid cartilage

INSERTED—into the lower border of the thyroid

ACTION.—It makes the true vocal cord tense

4 THYRO-ARYTENOIDEUS

ARISES—from the angle between the alæ of the thyroid.

INSERTED—into the front surface of the base of the arytenoids, some of the fibres are also inserted into the true vocal cord.

ACTION —They relax and support the true vocal cords.

THE NERVES OF THE LARYNX

The following branches of vagus supply the larynx —

(1) Superior laryngeal, (2) Inferior laryngeal.

SUPERIOR LARYNGEAL has two branches—

(1) INTERNAL BRANCH —Sensory to the mucous membrane of the larynx, and also sends a filament to the root of the tongue in front of the epiglottis

(2) EXTERNAL BRANCH —Motor to crico-thyroid, and part of arytenoid

INFERIOR LARYNGEAL —Motor to all the intrinsic muscles, except the crico-thyroid, and part of the arytenoid If the nerve is cut on one side, all the muscles on that side are paralysed except the crico-thyroid The voice becomes very imperfect though one can still speak a little When the nerve is cut on both sides, the voice is lost There is a peculiar choking sensation as the glottis closes, and there is also a peculiar whistling sound produced during inspiration

CUT THE SUPERIOR LARYNGEAL NERVE—

There is a loss of sensation and paralysis of the crico-thyroid, and the power to produce notes is lost Stimulate the upper end, there is instant reflex closure of the glottis, and a movement of deglutition, because a filament goes to the tongue

THE USE OF LARYGOSCOPE—

1 Physician sits opposite to patient with mirror adjusted to his head

2 Lamp behind patient's ear

3 Direct patient to protrude his tongue

4 Reflect light in the mouth

5 Hold the tongue between thumb and index finger in handkerchief

6 Hold the laryngeal mirror like a pen and warm it.

7 Place its back gently against the uvula

8 Patient is to draw deep breath, and say '*ah*' '*eh*'

APPEARANCE OF THE LARYNX AS SEEN BY THE LARYNGOSCOPE—

1 The root of the tongue.

2 The epiglottis

3 A narrow fissure, the rima glottidis

4 True vocal cords

5 The ventricles of the larynx

6 At each side two rounded elevation corresponding to the cartilage of Wrisberg and Santorini

7 In deep inspiration one may see the bifurcation of the trachea

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CHAPTER XII.

CONNECTIVE TISSUES.

By the term connective tissues is meant a group of tissues which differ from each other structurely, yet agree in the property of binding or connecting together other tissues of the body This group of tissues are divided into the following groups —

I Adipose tissue.
II. Neuroglia
III. Gelatinous or mucous connective tissue
IV Retiform tissue
V. Fibrous tissue
VI. Cartilaginous tissue.
VII Bone or osseous tissue

I ADIPOSE TISSUE

The adipose tissue is found in almost all parts of the body The principal situations where it is not found are—

(1) Subcutaneous tissue
(2) Eyelids
(3) The penis
(4) Scrotum
(5) The nymphi
(6) Lungs and brain

The amount of adipose tissue varies in different individuals It consists of cells which are number of vesicles varying in size Each fat cell possesses the following parts —

(*a*) A thin colourless envelope
(*b*) A central mass of yellow fat
(*c*) A nucleus placed eccentrically between the oil and envelope

CONSTITUENT PART OF FAT—

It chiefly consists of *tri-palmatin*, *tri-olein*, with a little *tri-stearin—palmatic*, *oleic*, and *stearic acids* united with glycerine After death the palmatin and stearin often form into needle-shaped crystals called "Margarin" crystals The yellow colour of fat is due to a pigment

FUNCTION OF ADIPOSE TISSUE—

(1) It forms a soft elastic cushion in the orbit for the eye It gives softness to the skin and roundness to the body, and diffuses pressure, as in the sole of the foot and the gluteal region

(2) It retards the radiation of heat

(3) It forms a store of food for the needs of the economy.

DEVELOPMENT OF FAT CELLS

They are probably developed from the connective tissue corpuscles, or some modification of them The fat appears as fine globules amidst the protoplasm, these globules coalesce, and push the nucleus and the protoplasm to one side, which latter may, to a great extent, disappear, although at first it forms a continuous layer around the fat Fat cells are largely supplied with blood-vessels, and are usually developed close to them As the amount of fat increases, new blood-vessels are formed

II NEUROGLIA —It is connective tissue of the central nervous system and of the retina It consists of small round corpuscles embedded in a soft undifferentiated protoplasm.

III GELATINOUS OR MUCOUS CONNECTIVE TISSUE —It is connective tissue of the embryo and the vitreous humour It forms Wharton's jelly in the umbilical cord It is soft and jelly-like in consistency.

IV RETIFORM TISSUE —This is connective tissue of the lymphatics and other glands which possess adenoid tissue It consists of stellate branching cells, the branches

of which blend with each other forming a network of anastomosis In the lymph glands, the lymph corpuscles are set in the meshes of this network

V FIBROUS TISSUE —This connective tissue is divided into two groups, viz , *white* and *yellow*

WHITE FIBROUS TISSUE —It is true connecting structure It serves to bind bones together in the form of *ligaments* It serves to connect muscles to bones in the form of *tendon.* It forms protecting structure in the form of membranes, *e g*, muscular sheath, periosteum, perichondrium, and sheath of nerves

They consist of delicate filament united together in bundles The bundles have very wavy course, and the filament in each bundle lies parallel to each other The filaments, and as well as bundles, are held together by cement The firmness of adhesion varies, but it is more marked in tendons and ligaments

YELLOW ELASTIC TISSUE —The connective tissue is named elastic tissue, as it consists of large amount of elastic tissue It is characterised by—

(1) Pale yellow in colour.

(2) Length indefinite, and very curly at the end

(3) Branch and anastomose with each other

(4) The fibres are very extensible, and when relieved from the stretching force, they recoil to their original length

This connective tissue exists in two forms—

(*a*) Fibrous

(*b*) Membranous

THE FIBROUS FORM is found—

In ligamentum nuchæ

In ligamentum subflava

Between the rings of the trachea.

In the true vocal cords

THE MEMBRANOUS FORM is found chiefly in the inner coat of arteries and veins "The fenestrated membrane of Henle"

VI CARTILAGINOUS TISSUE —Cartilage is a non-vascular structure which is found in various parts of the body, in adult life chiefly in the joint and thorax, etc. It is of greater importance in the fœtus, and in the immature condition of the body than in the adult, for in early life the bones are formed of it As the development and growth proceed, this cartilage is replaced by bone and is called, therefore, temporary, and the cartilage which remains as cartilage throughout life is called permanent

The cartilage consists of cells included in a strong, firm, continuous fibrillated or homogenous matrix The following varieties of cartilage based on modification of structure —

1 CELLULAR cartilage does not exist in the adult human body It occurs in the human embryo In this form there is no matrix, being composed entirely of cells It is found in the ear of the rat, mouse, etc

2 CELLS, with distinct matrix—

(1) MATRIX homogenous, like ground glass, without distinct structure is *Hyaline cartilage.*

(2) MATRIX FIBROUS—

(*a*) WHITE FIBRO-CARTILAGE —It has white fibrous tissue

(*b*) YELLOW FIBRO-CARTILAGE —It has yellow fibrous tissue

HYALINE CARTILAGE —It is elastic, tough and pliable, in mass it is opaque and pearly It consists of cells embedded in a hyaline matrix

THE CELLS consist of masses of granulated protoplasm round oi angular in shape The protoplasm is spongy and fills the space The cells lie singly or in groups of two or three The cells lie in a distinct capsule formed by the matrix

THE MATRIX or intercellular substances is hyaline and faintly granular It is homogenous resembling ground glass

In the articular cartilages the arrangement of the cells differ from the ordinary cartilage

1 Near the free surface the cells are flattened and lie parallel with the surface

2 Below this they form irregular groups

3 Near the bone the cells are arranged in parallel rows, perpendicular to the surface of the bone on which the cartilage rests

In costal cartilages the cells are in groups, several cells being within one capsule The matrix is more distinctly fibrillated

SITES—It forms articular cartilages, also costal, ensiform, trachea, bronchi, thyroid, cricoid, arytenoid cartilages, and cartilages of nose

WHITE FIBRO-CARTILAGE—

It is found in the intervertebral discs, sacro-iliac synchondrosis, symphysis pubis, interarticular cartilages, glenoid and cotyloid ligaments, semilunar cartilages, &c It consists of cells, the cells are ovoid in form and nucleated The cells are in capsule The matrix consists of fine colourless fibrils The fibrous matrix is more distinct in the peripheral than the central part

YELLOW-FIBRO CARTILAGE—

It is also called spongy or elastic cartilage It is more flexible, has a yellow colour, and a spongy appearance It is found in the epiglottis, outer ear, and in the Eustachian tube

It consists of an elastic fibrous network, like that of elastic tissue The cells are rounded or ovoid, distinctly nucleated, and usually arranged singly or in pairs. The matrix is fibrous, the fibres form a close network. The yellow fibro-cartilage has no tendency to ossify.

MEMBRANE OF CARTILAGE—

It is called perichondrium It is a vascular fibrous membrane, which covers the cartilage except the articular cartilage

VII. BONE OR OSSEOUS TISSUE

The bone is that which constitutes the hard frame-work of the skeleton It protects the delicate organs, as the brain and spinal cord. It supports the limbs and trunks, and acts as levers for muscular movements

PROPERTIES OF BONE

1. PHYSICAL —It is *hard* due to the presence of lime salts, chiefly phosphate of lime It is more or less dense, tough and slightly elastic The elasticity is more marked in young than adult If a bone be burned, it first chars, and then only the ash remains and the shape of the bone is preserved

2 CHEMICAL

The solids consist of about one-third *animal matter* and two-thirds *earthy matter*, and which contains phosphate of lime in abundance The following matters are found in the bone —

(1) Collagenous substance or *animal matter*, which is converted into *gelatin* by boiling.

(2) Earthy matters are .—

(*a*) Calcic phosphate

(*b*) Calcic carbonate

(c) Calcic fluoride

(*d*) Magnesic phosphate

(*c*) Sodic chloride

THE PARTS OF BONE—

1 THE PERIOSTEUM —It is fibrous membrane investing externally the bone

2 COMPACT OR DENSE TISSUE —It is hardest part of bone forming a dense external shell.

3 CANCELLATED OR SPONGY TISSUE.—It is the interior of bone, and it is called spongy being much less firmer This part is especially found towards the extremities of the bone, at the articular end

4 MEDULLARY CANAL —It is the central cavity in every long bone containing marrow.

1. THE PERIOSTEUM —It is a strong fibrous membrane which clothes the bone everywhere, except at the articular surface It contains numerous arteries which ramify before they enter the bone The arteries pass into the compact through a small hole where they ramify in the Haversian canals It supplies nourishment to the bone.

STRUCTURE

It consists of two layers—

(1) OUTER LAYER —It is composed of elastic and white fibrous tissue containing many blood-vessels

(2) INNER LAYER —This layer is well marked in young growing bone This is soft layer consisting of a network of fine fibrils, in which rounded nucleated cells, *osteoblasts* or "bone-forming cells" are found. This portion of periosteum is concerned in the formation of bone

STRUCTURE OF BONE

The structural element of bone consists of cells embedded in a fibrous matrix The cells or bone-corpuscles lie in spaces called *Lacunæ*. Neighbouring Lacunæ communicate each other by canals called Canaliculi They penetrate the matrix and probably serve as lymph channels

If the outer surface of the compact tissue and the wall of the medullary canal be examined by lens, they will be

seen to be riddled by numerous minute openings, which are mouths of passages that traverse the compact tissue

MICROSCOPICALLY

The compact tissue shows network of canals (Haversian canals), containing blood-vessels, and running longitudinally or obliquely through the substance to open either on its outer surface, or on the inner surface In addition to this there are spaces called Haversian spaces The matrix of the bone which surrounds the canals is seen to be arranged in concentric rings, as if it were built up of a series of *lamellæ* or plates as follows —

1 PERIPHERIC LAMELLÆ —They are arranged immediately under the periosteum.

2 HAVERSIAN LAMELLÆ —They are arranged round the Haversian canals Each Haversian canal with its lamellæ of lacunæ constitutes an *Haversian system*

3 INTERMEDIATE LAMELLÆ, forming irregular groups between the Haversian system

4 PERI-MEDULLARY LAMELLÆ —They are arranged round the medullary cavity These lamellæ are perforated by fibres called *Sharpey's fibres* These fibres pierce the lamellæ so as to unite the peripheric with intermediate lamellæ

MEDULLARY CANAL —It is central space in the long bone It is lined by a thin vascular membrane, the endosteum The medullary canal contains marrow, and cancellous tissue at the ends of the bone is also occupied by marrow

THE MARROW—

It occurs in two forms,—red and yellow

YELLOW MARROW is found in the medullary canal of long bones, and it chiefly consists of fat-cells with blood-vessels

RED MARROW —It is found in the spongy tissue at the ends of the long bones of the limb, in short bones, ribs, and in all the flat bones It is blood-forming organ

COMPOSITION OF RED MARROW—

It consists principally of large many-nucleated masses of protoplasm called *osteoclasts* These osteoclasts eat away bone during certain stage of development of bone It also contains delicate connective tissue, with many blood-vessels and a great number of marrow-cells It contains very little or no fat, whereas yellow marrow is almost all fat

THE DEVELOPMENT OF BONE

There are two modes of developing bone—

(1) Intra-cartilaginous By the ossification in *cartilage*

(2) Intra-membranous By the ossification in *fibrous* membrane

INTRA-CARTILAGINOUS OSSIFICATION

I When process of ossification begins, a change takes place in the arrangement of cartilage cells The cells of temporary cartilage, arrange themselves in longitudinal parallel rows In each row the cells lie with their long axis transverse, and multiply by a process of fission The cells at the end of rows which are near the centre of ossific change swell out and become rounded Calcification of matrix takes place, which includes the capsule of the cells Now the cells become separated and scattered from each other

II The spaces called medullary spaces are formed in the ossifying cartilage These spaces contain blood-vessels by the prolongation of blood-vessels of perichondrium, and spaces are lined by a layer of rounded cells These cells undergo certain modification which follows —

1 A few become elongated into fusiform

2 Some become osteo-blast which are the direct agents in the formation of bone

3 Others again have oil drops, and become cells of yellow marrow

4 Others become corpuscles of red marrow

III The formation of medullary spaces are due to absorption of cartilaginous tissue by many-nucleated cells

derived from osteoblasts As the absorption of the cartilage goes on, the series of medullary spaces, communicating each other are produced. But along with destructive changes in the cartilage the production of new osseous tissue goes on

IV Some of the cells of medulla arrange themselves in layers around the walls of the medullary space The protoplasm of the cells hardens from the periphery towards the nucleated centre of the cells The hardened protoplasm becomes matrix giving rise to lamellæ of the bone The nucleus remains soft which gives origin of lacunæ and canaliculi By the repetition of this process around the walls of the several medullary spaces, the successive lamellæ of the bone are produced The formation of successive lamellæ diminish the size of the medullary spaces, which then forms the Haversian canals

Bone growes in length by the ossification in the cartilage found at the point where the epiphysis joins the shaft

Bone grows in thickness The growth in thickness comes from the osteogenitic layer of the periosteum, similar to those which lie in the medullary spaces of the fœtal cartilage

INTRA-MEMBRANOUS OSSIFICATION

The intra-membranous ossification is that by which the bones of the vertex of the skull are formed The *membrane* which occupies the place of the future bone become more vascularised, and a network of minute bone *specules* radiating from the centre of ossification shoot out in all directions towards the periphery The radiating specules consist of fibres (osteogenic fibres), and multitude of granular corpuscles or osteoblasts and of blood-vessels The osteoblasts investing the fibres calcify or hardens from periphery to the centre, and pass through series of changes similar to those described in intra-cartilaginous mode of ossification.

The fibres also calcify, and they undergo into formation of the bone Thus, the intra-membranous and intra-cartilaginous process of ossification are similar in their essential features The increase in thickness of a bone takes place through the periosteum.

CHAPTER XIII.

PHYSIOLOGY OF MUSCULAR TISSUE

The muscular tissue, which is popularly known as flesh, forms a large proportion of the general mass of the body, and also enters in the formation of walls of the hollow viscera It is the active agent, therefore, concerned both in motion and locomotion It consists structurally of threads or fibres, some of which are marked by *stripes*, and others are not marked Thus it is divided into—

(1) STRIPED (*voluntary*)

(2) *Non-striped* (*involuntary*)

Now again, the *striped* muscles are under the influence of will, therefore called *voluntary*, and there is an exception to this rule, the muscular fibres of the heart are striped, but it is not under the control of the will, therefore it is *involuntary* The *non-striped* muscles are not in any way subject to the influence of the will, therefore it is called *involuntary*

THE NON-STRIPED OR INVOLUNTARY MUSCLES are found in all hollow viscera, *e g*, in the alimentary canal below the middle of the œsophagus, in the trachea and bronchi, and in the gall-bladder, in arteries, veins, and lymphatics, in the bladder, ureters, urethra, and in the male and female genital organs, also in the skin, iris, and ciliary muscle It is composed of long fusiform cells or fibres.

THE FIBRES OR CELLS OF NON-STRIPED MUSCLES

The fibres are usually collected into bundles or *fasciculi* The fasciculi are separated from each other by a delicate connective tissue, or *perimysium* The fibres or cells are longitudinally striated, and tapering at the ends The fibres are pale, colourless There is an axial band of very fine homogenous fibrils, a single rod-shaped or oval nucleus situated in the middle with a membrane, and inside this a delicate reticulum No cell wall or *sarcolema* can be distinguished

Fig 37 —Long fusiform cell or fibre shows longitudinal striation and nucleus

STRIPED OR VOLUNTARY MUSCLES

The striped muscles are found wherever energetic work is to be performed The fibres in these muscles are collected in a *fosciculi* or bundles The fibres are parallel to each other from tendon of origin to tendon of insertion The surface of a muscle is enveloped in a connective tissue called

EPIMYSIUM—

This sends septa, carrying blood-vessels and nerves, into the substance of the muscle dividing it into different compartments, containing bundle of fibres, the sheath of each bundle may be called *Perimysium* The individual fibres are intervened by loose connective tissues containing capillaries, called *Endomysium*

EACH FIBRE CONSISTS OF THE FOLLOWING PARTS —

(1) SORCOLEMA it is transparent, homogenous, elastic, and tough It encloses sarcous substance and at certain places it is connected with it

(2) NUCLEI OR MUSCLE CORPUSCLES.—These are found immediately beneath the sarcolema in all mammals The nuclei are flattened, and occur at irregular intervals, and are surrounded by a little undifferentiated protoplasm

(3) SARCOUS SUBSTANCE —This is composed of contractile fibrils The sarcous substance is marked transversely by clear and dim stripes alternately Each fibre is striated longitudinally These striation being the outlines of fibrils, each fibre is thus composed of a mass of fibrils. Each fibril consists of alternate segments of the dim and clear bands The segments forming the dim stripe represent the "Sarcous substance of Bowman" The dim segments are not uniform, but have three swellings, one at each end and one in the middle.

DOBIE'S LINE —A fine dark line runs across the centre of the clear stripe There is one in each fibril, and it causes the clear stripe to bulge

1 There is also a stripe across the middle of the dim stripe known as "*Hensen's line*"

2 The dim stripe is contractile and elastic, while the clear stripe is only elastic, not contractile

MUSCLE OF THE HEART —The fibres of the muscle of the heart are striped, but they are involuntary They have no sarcolemma, and usually only one nucleus in the centre of the fibre The fibres anastomose with each other The transverse striation is not so distinct The cardiac muscle stands midway between striped and non-striped muscle Its contraction takes place much more slowly, and is much more prolonged than in ordinary striped muscle

RELATION TO TENDON

The connective tissue of muscular fibres pass from the end into the connective tissue of tendon, and there they both get united together by special cement The tendon consists of white fibrous tissue enveloped in a loose tendon-sheath The tendon sheath contains mucous fluid in which the tendon moves

BLOOD-VESSELS OF MUSCLES

Muscles are abundantly supplied with blood The blood-vessels ramify in the perimysium, while the capillaries lie in the endomysium outside the sarcolemma

CHEMICAL COMPOSITION OF MUSCLE

Living muscle in resting condition is alkaline in reaction, and during contraction reaction is acid due to production of *sarco-lactic* acid It rapidly undergoes a great change after death It consists of the following composition —

(1) Water	75 per cent
(2) Solids	25 ,,

(*a*) Proteids and albuminoids, 21 per cent
(*b*) Extractives, and salts, 4 per cent
(*c*) Pigments—Hæmoglobin, myohæmatin

EXTRACTIVES

(*a*) NITROGENOUS—creatine, creatinine, hypo-xanthine, xanthine, uric acid, urea, fats

(*b*) NON-NITROGENOUS—Glycogen, inosite glucose, sarco-lactic acid

SALTS—The salts are chiefly potassium, especially potassium phosphate

MUSCLE PLASMA—or muscle juice can be obtained in the following ways —

(1) From dead muscle remove all the fat, tendon, &c , and wash in water until the washings contain no trace of proteids Then treat with a 10-per cent solution of NaCl, which will dissolve a large proportion into a viscid fluid

Filter, and then drop the viscid filtrate little by little into distilled water, when a white flocculent precipitate of *myosin* will be thrown down

(2) From living muscle freeze and rub up in a mortar with snow and a 1 per cent solution of NaCl, when a fluid will be obtained (the muscle plasma) Filter at first the fluid is liquid, but slowly coagulates spontaneously, the clot is *myosin*, and the fluid which is squeezed out is blood-serum

The clotting results from coagulation of two proteids—(1) Myosinogen, (2) Paramyosinogen

CHEMICAL COMPOSITION OF MUSCLE PLASMA.

Paramyosinogen

Myosinogen

Myoglobulin

Albumin

Myo-albumin

(*Halliburton*)

MYOSIN

It belongs to the globulin family, and is soluble in strong solution of common salt It is soluble in dilute alkalies It coagulates at a lower temperature than serum-albumin. Dilute acids, as Hcl, change it into syntonin or acid albumin Myosin may be extracted from muscle by a 10-per cent solution of NH_4 Cl, and if it be heated, it is precipitated again

CONDITION OF MUSCLE IN LIFE AND IN DEATH

In life the "sarcous substance" is semi-fluid At death it coagulates and forms clot and serum This is due to the coagulation of myosin, it is in this "rigor mortis" occurs, that is muscle becomes rigid The reaction becomes intensely acid, and much CO_2 is given off, though there is no consumption of oxygen

METABOLISM IN MUSCLES

The chemical changes taking place in muscles can be studied in the following ways —

(1) Analysis of muscle at rest and after prolonged contraction

(2) Analysis of blood entering and leaving the muscle during contraction

(3) Analysis of the excreta, especially from the lungs and kidneys during rest and exercise.

1 A MUSCLE DURING REST —Muscle absorbs O from the blood flowing in and returns CO_2, but the amount is less than O absorbed The reaction is alkaline

2 A MUSCLE DURING ACTIVE EXERCISE—

(1) The reaction becomes acid due to production of sarco-lactic acid

(2) Blood-vessels become dilated, therefore more nutrition to muscle and return of venous blood is hastened

(3) It respires more rapidly, the excretion of CO_2 is more rapid, and there is a greater amount of O consumed

(4) The amount of glycogen in the muscle is diminished.

(5) EXTRACTIVES—On active muscles contain less extractive, less fat, less creatine and creatinene

(6) The amount of urea excreted is not increased during exercise.

SOURCE OF MUSCULAR ENERGY

FICK'S AND WISLICENN'S EXPERIMENT

They omitted proteids from their diet, before, during, and for some hours after the performance of some mechanical work. This was done in ascending the Mountain Alpe They estimated the total amount of nitrogen excreted by the kidneys before, during, and after the work, and found that it was not increased. Therefore they concluded that proteid is not necessary for muscular work

PARKES' EXPERIMENT.

He made similar experiment on soldiers doing mechanical work on a non-azotised diet He estimated the total nitrogen excreted in the urine and fæces, and found that it was not increased by mechanical work

The fact established from these experiments that muscular energy does not spring from the proteid, but all three of the chief groups of food stuffs—carbo-hydrates, proteids and fats are the source of muscular energy

RIGOR MORTIS OR CADAVERIC RIGIDITY.

It results from spontaneous coagulation of myosin The muscle becomes stiff or rigid, shorter and thicker and more easily torn or ruptured It begins in the muscles of the lower jaw and neck, extending thence to those of the face, front of neck, upper extremities and chest, and finally to the lower limbs.

PHYSICAL PROPERTIES OF MUSCLE

I THE ELASTICITY OF MUSCLE—The elasticity of muscle is small in amount, but perfect in quality, *i e*, when a muscle is stretched, it readily extends, and when the stretching power is removed, in virtue of its elasticity it regains its former length

TONE OF A MUSCLE—It means firm, braced-up condition of a muscle. It feels firm and not flabby When a muscle is divided, the ends retract and the wound gapes. These all confirm that muscle is in a state of tension, and this tension is spoken "tonacity of the muscle" It is due to elasticity The tone of the muscle is diminished by—

(1) Fatigue

(2) Defective nutrition

(3) Weak, relaxed state of the system

FUNCTIONS OF ELASTICITY OF MUSCLE—

(1) The muscle is kept in a state of slight tension, or kept tight, so that at the moment of contraction, time is not lost, nor energy wasted in bracing it up

(2) The elasticity lessens the shock of the contraction, so that the muscles are not liable to be torn from their attachments

II THE EXCITABILITY OF MUSCLE.

It is a property of a muscle, in virtue of which it can be thrown into contraction by the application of various forms of stimuli The muscle becomes shorter and thicker and thus work and heat are emitted from the muscle

The excitability of the muscle is inherent property, that is, it contracts on direct application *of stimuli* on the muscle. This quality of a muscle is independent of the existence of motor nerve Curara paralyse the peripheral end of motor nerve in muscle, but it does not diminish the excitability of the muscle It contracts when stimuli are applied directly

THE STIMULI ARE —

Chemical
Mechanical
Thermal
Electrical.
Nervous

(1) CHEMICAL STIMULI —Mineral acids, acetic, oxalic acids, the salts of iron, zinc, copper, all act in weak solution as muscular stimuli

(2) MECHANICAL STIMULI —Every kind of sudden mechanical stimulus applied to a muscle causes contraction

(3) THERMAL STIMULI —Heat excites the excitability of muscle If the temperature be too high, however, the muscle passes into a state of rigor mortis Cold lessens the excitability.

(4) ELECTRICAL STIMULI —The galvanic current stimulates the muscles to contraction directly and independently of nerves, so that in a muscle with paralysed motor nerves, the galvanic will stimulate to contraction when the fradic fails

(5) NERVOUS STIMULI —*Vide* Text-book

CHANGES TAKE PLACE IN A MUSCLE DURING CONTRACTION—

(1) Change in form it shortens and thickens

(2) Chemical changes—

(a) Much CO_2 is produced, and more O used up.

(b) Sarcolactic acid is produced , and this

(c) Changes the reaction from alkaline to acid.

(d) Glycogin is diminished.

(3) The heat is produced

(4) The blood flowing from a contracting muscle is more venous than that from a muscle at rest

(5) The muscular sound is produced

(6) Change in elasticity and extensibility the extensibility is increased, while elasticity is diminished.

MUSCULAR CONTRACTION—

When a muscle stimulated results into contiaction. It takes $\frac{1}{10}$th of a second to complete whole contraction The number of contraction depends upon the application of the number of stimuli

1 SIMPLE CONTRACTION —This means a single contraction If a single stimulus (or induction shock) be applied to a muscle, iesults into a single contiaction (or twitch), *i e* , the muscle rapidly shortens and quickly returns to its original state

2 COMPOUND CONTRACTION —This means a succession of single contraction, *i e* , the muscle is kept up into by the successive application of stimuli.

PHYSIOLOGICAL TETANUS—

When induction shocks are applied to a muscle or its nerve in quick succession, the relaxation of the muscle becomes incomplete, and if the shocks are sufficiently rapid, the single contiaction become, so completely fused together that the line representing the contractions seems as if due to a single or simple contraction. The condition is known as " Physiological Tetanus "

CONTRACTION CURVE OF MUSCLE—

When a muscle is stimulated by a single induction shock, four events follow —

(1) THE "LATENT PERIOD"—The period between the entrance of the current and the appearance of the visible contraction, *i e*, the muscle does not begin to contract the moment the stimulus is applied, but the contraction occurs a little later Although there is no visible change in the muscle during this period, but it is believed recently that some change does occur in the substance of the muscle The change consists that natural electrical current of the muscle is diminished during this period and it is spoken of as "*Negative Variation*"

(2) THE "PERIOD OF CONTRACTION"—The evolution of energy, *i e*, the period that the muscle begins to shorten until it reaches its greatest degree of contraction

(3) "PERIOD OF RAPID RELAXATION."—The period during which muscle begins to relax after the contraction.

(4) THE "PERIOD OF SLOW RELAXATION"—It is named residual contraction due to elasticity of the muscle

THE MUSCLE SOUND —A distinct semi-musical sound is produced in muscle during its contraction due to a series of regular rhythmical vibrations and not to a single impulse It is low rumbling sound. The sound indicates that every voluntary contraction, not instantaneous, is a compound contraction, and is due to a succession of 19½ nerve impulses projected from the brain every second

THE AMOUNT OF CONTRACTION OF ANY MUSCLE DEPENDS—

(1) On the strength of the stimulus

(2) On the resistance to be overcome.

(3) On the length and energizing power of the muscle if stimulated again and again it becomes fatigued and the amount of the contraction decreases A fatigued muscle requires a stronger stimulus to produce the same amount of contraction

CHAPTER XIV.

NERVOUS SYSTEM

NERVOUS TISSUE, PERIPHERAL NERVES, CENTRAL NERVOUS SYSTEM

NERVOUS TISSUE—

STRUCTURE OF THE NERVE ELEMENT –

The nervous elements consist of two distinct parts, viz —

I NERVE-FIBRES

II NERVE-CELLS

I NERVE FIBRES—

The nerve fibres are met with two kinds of fibres—

(1) MEDULLATED or white

(2) NON-MEDULLATED or grey, pale

MEDULLATED OR WHITE NERVE FIBRES

Are chiefly found in the cerebro-spinal nervous system. Nerve fibres do not branch in their course, but only at their central or peripheral termination

THE FIBRE CONSISTS OF THE FOLLOWING PARTS—

(1) PRIMITIVE SHEATH OR NEURILEMMA —It lies outside the white sheath, it dips down a little at the nodes of Ranvier It is colourless, transparent, and structureless On its inner surface there is a clear oval nucleus

(2) NUCLEUS OR NERVE-CORPUSCLE —It lies inside of the primitive sheath in the depression of medullary sheath There is usually one between each node

(3) MEDULLATED SHEATH —(white sheath or white substance of Schwann) This lies between primitive sheath and axis-cylinder It is not continuous, is not found at the central nor peripheral end, and there are also gaps in it throughout its course, these gaps are known as the "*Nodes of Ranvier*" It consists of fatty and albuminous substances which refracts light strongly Surrounding the axis cylinder is a honeycomb-like stroma, the meshes of which are filled with "*myelin*" This is soft, semi-fluid, fatty in nature, containing both nitrogen and phosphorous The honeycomb framework is formed of neuro-keratin

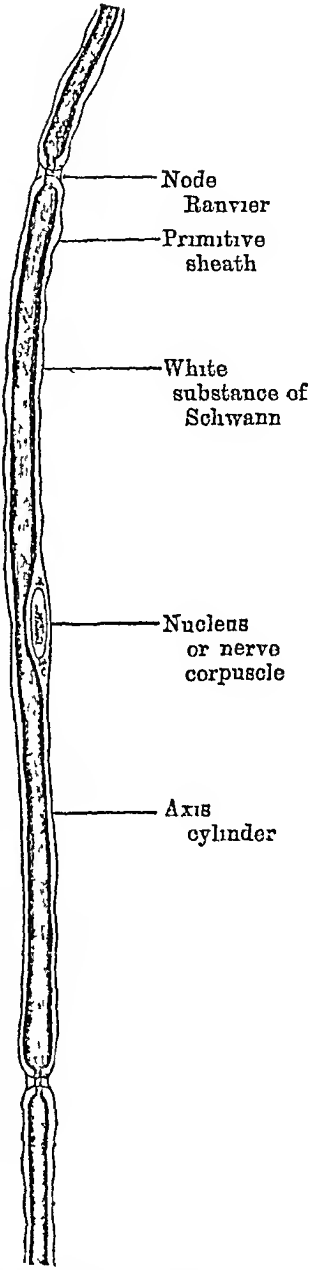


Fig 38 Nerve fibre

FUNCTION —It acts as insulator by which nerve motion is prevented from spreading, and also it is protective

(4) AXIS CYLINDER —A cylindrical band in the centre, covered only by medullary sheath. It is formed by bundles of nerve fibrils imbedded in a clear or finely granular interstitial matter It is the part of fibre which first appears in the course of development Sometimes it forms the only constituent of a nerve fibre at its central and peripheral termination, and therefore, it continues with nerve-cells or with end-organs It is very important structure into the nerve fibre, as this part of the nerve fibre is directly concerned in the conduction of nerve impulses.

Nerve is invested with sheath of connective tissue thus —

(1) GENERAL PERINEURIUM which surrounds the nerve trunk, and passes into the nerve, and subdivide it into fosciculi called—

(2) SPECIAL PERINEURIUM —This surrounds each fosciculus sending inwards a prolongation called—

(3) The *endoneurium* inside each bundle, and round each fibre contains nutrient blood- vessels

2 NON-MEDULLATED OR GREY NERVE FIBRES —These fibres are chiefly found in the *sympathetic* nervous system, and in the fibres of *olfactory* nerve and in the *peripheral* terminations of the cerebro-spinal nerves. All nerve fibres in the first stage of development are non-medullated It is characterised by the absence of medullary sheath.

STRUCTURE—

1 They consist of a bundle of very fine fibrils These fibrils form the *axis cylinder*, and are held together by cement

2 PRIMITIVE SHEATH OR NEURILEMMA—invests the fibrils, with a nucleus here and there on its inner wall.

3 NUCLEI —These are also found in the substance of fibres, and in relation with primitive sheath.

EFFECT OF REAGENTS ON THE VARIOUS PARTS OF NERVE FIBRES —

1 The axis cylinder is stained red by picro-carmine, and medullary sheath is unaffected by it.

2. CHROMIC ACID stains the primitive sheath opaque or brown

3 OSMIC ACID stains the medullary sheath black, on account of its fatty nature, and also reveals the " Node of Ranvier "

II NERVE-CELLS

Nerve-cells constitute an important part of nerve tissue, as by molecular changes in their structure they produce nerve energy.

STRUCTURE—

Nerve-cells are nucleated, the nuclei are large, and contain one or often nucleoli The cell substance is granular The nerve-cells in the grey matter of the brain and spinal cord are imbedded in the neuraglia The nerve-cells of sympathetic ganglia and of the ganglia on the posterior roots of spinal nerves are surrounded by capsule of connective tissue The body of the cells gives off two or more *processes* or *poles projecting,* which gradually spread out and form on all sides a surrounding network, and as each cell presents a similar arrangement, so the result is that a close union between them is produced The cells are of various *forms* according to the number of their *processes*

FORMS OF NERVE-CELLS—

1 UNIPOLAR CELLS —They have only one pole.

2 BIPOLAR CELLS —They have two poles, and are best developed in fishes

3 MULTIPOLAR CELLS —They possess many poles, consisting of a nucleated mass of protoplasm They are found—

(1) In the anterior horn of the spinal cord

(2) In the grey matter of the cerebrum They are pyramidal in shape The apex is directed to the surface of convolution, the base towards the white matter

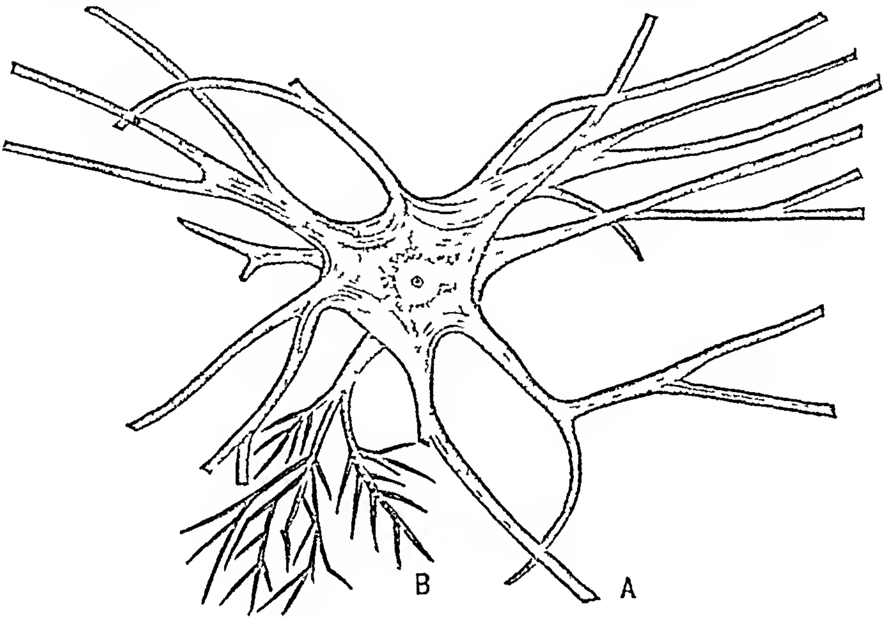


Fig 39

Multipolar nerve cell, (A) axial cylinder process, (B) protoplasmic processes

THE PROCESSES OF MULTIPOLAR CELL —They are of two kinds, viz —

(1) AXIAL-CYLINDER PROCESS —This process remains unbranched, and soon becomes covered with primitive and medullary sheaths, so that it becomes axis cylinder of a nerve fibre

(2) PROTOPLASMIC PROCESSES —The process which divide and subdivide into several branches By means of these processes the adjoining cells communicate each other, so that impulses can conduct from one cell to another

4 NERVE-CELLS WITH CAPSULE —The cells which have distinct capsule occur in the sympathetic ganglia The cells are pear-shaped, and from the narrow end of

the pear two processes arise, one is called *straight* and the other is named *spiral* fibre

5 PURKINGE'S CELLS —They are found in the cerebellum They are *globular* or *pear-shaped* cells with a slender central process, and from the opposite or peripheral aspect of the cell there are two strong, *antler-like* branching processes

NEUROGLIA —It is the connective tissue of the nervous element containing blood vessels It forms "network throughout the nervous system cementing the cells together, while at the same time it serves then as a means of nutrition

FUNCTION OF NERVE-FIBRES AND NERVE-CELLS—

THE NERVE-CELLS transmit nerve-energy and act as centres for automatic or reflex movements, and also the censory, perceptive, trophic, and secretory functions

THE NERVE FIBRES conduct nerve energy evolved from the cells

CHEMICAL COMPOSITION OF NERVE-TISSUE —

Chemical Composition of	Grey Matter	White Matter
Water	81 6 per cent	68 4 per cent
Solids	18 4 „	31 6 „
Total	100 0 „	100 0 „
The solids consist of —		
Proteids	55 4 „	24 7 „
Lecithin	17 2 „	9 9 „
Cerebrin	0 5 „	9 5 „
Cholesterin and fats	18 7 „	52 1 „
Extractives	6 7 „	3 3 „
Salts	1 5 „	0 5 „
Total	100 0	100 0

PROTEIDS—

(1) ALBUMEN occurs chiefly in the axis-cylinder and in the substance of cells

(2) NUCLEIN occurs chiefly in the grey matter
FATS are found especially in the white matter.
PROTAGON, which contains N P, is mixture of *lecithin* and *cerebrin*

LECITHIN—It is a *nitrogenised* and *phosphorised* fatty body, and consists of C,H,O, N and P It is a white crystalline substance, soluble in hot alcohol and ether When it is decomposed, it splits up into *glycero-phosphoric* acid and *oleo-phosphoric acid* In wasting diseases of nervous system, there is an increase of phosphates in the urine The phosphorus comes probably from the decomposition of lecithin

PHYSICAL PROPERTIES

One of the most remarkable property is that nerve-fibres are not elastic when divided nerves do not retract, while tendon retracts The nerves exhibit microscopically transverse folds

EXCITABILITY OF THE NERVES

Nerves possess the property in virtue of which they are capable of transmitting along itself, without any visible change in form, certain molecular changes set up by some stimulus, called "Nervous impulses" Nerves may be excited by the following various kinds of stimuli —

(1) MECHANICAL STIMULI, *e g*, *pinching, blow, pressure, tension, puncture*, and *section*, excite nerve, provided they are applied with sufficient rapidity

In the case of sensory nerves, when they are stimulated, *pain* is the result When a *motor* nerve is stimulated, the muscle supplied by the nerve contracts, thus "*motion*" The continued pressure may paralyse the nerve, as an aneurism of the arch of the aorta

(2) THERMAL STIMULI—The heat increases the excitability of the nerves The higher the temperature, the greater is the excitability and the shorter its duration

(3) CHEMICAL STIMULI excite the nerves, when they are acted upon with sufficient rapidity Most chemical

stimuli first increase the nervous excitability, and then diminish or paralyse it, e g, alcohol, strychnia, dilute acids, alkalies Sodium chloride excites only motor nerves

(4) ELECTRICAL STIMULI —The effect of electrical stimuli can be observed only when the nerve is connected with a muscle The electrical stimulation is followed by contraction of the muscle, in the case of sensory nerve sensation is the result

EXCITABILITY IN A NERVE DIMINISHED—

(1) By the defective blood-supply and interference in the normal nutrition of the nerves themselves

(2) By the fatigue of a nerve. Continued excessive stimulation of a nerve causes fatigue, and by exhaustion rapidly diminish the excitability

(3) By continued inaction of a nerve diminishes, and may ultimately abolish the excitability

(4) By separation from their nerve centres There is "trophic centre" within the nerves which governs the nutritive process When a nerve is separated from the centre, it loses excitability, and lastly undergoes degeneration

WALLERIAN LAW OF DEGENERATION

EXPERIMENT ON SPINAL NERVES

1 He divided the motor root and found that the peripheral end degenerated, but not the end next the spinal cord

2 He divided the posterior root between the cord and the ganglion, and the end next the spinal cord degenerated, but not the end next the ganglion.

3 He divided the congoined roots, and then found that, in the case of both motor and sensory fibres, the peripheral ends degenerated, whereas the ends next the spinal cord did not

4 He divided the posterior root on each side of the ganglion, and found that the ends next the ganglion did

not degenerate, while the other two did—peripheral in the one case, central in the other

CONCLUSION

He infers that there are centres that preside over the nutrition of nerves called "*Trophic centres*" These experiments show that the fibres of the anterior and posterior roots are governed by different trophic centres The trophic centre for the fibres of the anterior root lies in the multipolar cells of the *anterior horn* of the grey matter of the spinal cord

The traphic centre for the fibres of the posterior root lies in the ganglion placed on it

REGENERATION OF A NERVE AFTER DIVISION

When a nerve is divided, it reunites, provided the gap is not too large The function of the nerve is restored, in case of a mixed nerve, sensibility is restored first, subsequently voluntary motion, and lastly, the movements of the muscles If the ends of the divided nerve do not meet, the central end becomes bulbous

DEGENERATION OF A DIVIDED NERVE

If rapid reunion be prevented, the part supplied by the nerve is paralysed, whether sensory or motor, excitability is at first increased for a short time and then decreased The white sheath then seems to undergo fatty degeneration, and breaks up into little rounded oily-looking masses In two or three months it becomes very granular, and the grey sheath looks as if it had been filled with dust This disappears, leaving the grey sheath, nuclei, and axis cylinder

PERIPHERAL NERVES

CLASSIFICATION OF NERVE-FIBRES —The nerve-fibres are classified according to the function they perform When a nerve-fibre is stimulated, it is capable of conducting impulses in both directions from *periphery* to the centre or from *centre* to the periphery

FUNCTIONAL CLASSIFICATION FOLLOWS—

I EFFERENT OR CENTRIFUGAL—

(1) Motor
(2) Secretory
(3) Trophic
(4) Vaso-motor and vaso-inhibitory

II AFFERENT OR CENTRIPETAL—

(1) Sensory
(2) Inhibitory

III INTER-CENTRAL

I EFFERENT NERVES —Efferent fibres are those fibres which convey impulses from the centre to the periphery

1 MOTOR NERVES—are composed of those fibres by the excitation of which cause the muscle to contract

2 SECRETORY NERVES are those nerve-fibres which are attached to the secretory glands causing them to secrete

3 TROPHIC NERVES —They govern over the normal nutrition

4 VASO-MOTOR and VASO-INHIBITORY — are those nerve-fibres which go to the walls of blood-vessels so as to cause contraction or dilatation

II AFFERENT NERVES—are composed of those fibres which convey impulses from periphery to the centre For instance, when a finger is pinched, he feels pain in the finger, an impulse travels through the nerves to the spinal cord and then to the brain resulting into sensation

1 SENSORY NERVES contain those fibres which conduct sensory impulses to the central nervous system causing sensation The nerves of sensation may be classified as follows —

(*a*) THE NERVES OF GENERAL SENSIBILITY— Conveying to nerve centres in brain influences which cause sensation of a vague character, feelings of comfort and discomfort felt in the interior of the body.

(b) THE NERVES OF SPECIAL SENSE—conveying to nerve centres in brain influences which cause visual, auditory, gustatory, olfactory, or tactile sensation.

2 INHIBITORY NERVES—are those which affect other centres of nervous activity by inhibiting or neutralizing their action.

MOTOR ACTION is divided into—

I AUTOMATIC ACTION

II. REFLEX ACTION

I Automatic motor action may be—

(1) NERVOUS

(a) Involuntary, as the action of heart

(b) Voluntary, as in the movements necessary for speech.

(2) NON-NERVOUS, as ciliary motion.

II REFLEX MOTOR ACTION

The essence of reflex action is the transmutation by means of the irritable protoplasm of a nerve-cell of afferent into efferent impulses When ends of sensory nerves are stimulated, the impression being carried along sensory nerves to a central organ, where changes are excited which result in a discharge of nervous energy along motor nerves to various muscles Thus a frog in which the brain and medulla oblongata have been removed will draw up its limbs if the foot be pricked Such action taking place without consciousness is called *reflex action*

A reflex act requires a continuity between an afferent nerve and an efferent nerve The parts usually involved are—

(1) A receiving or sensory surface (*as skin*)

(2) A sensory nerve (*afferent fibre*)

(3) A receiving station (*nerve cell or centre*).

(4) A motor nerve (efferent fibre)

(5) Muscles.

This is the simplest form of mechanism, as found in the medulla oblongata In many cases, as in the spinal cord we may have two or more sets of nerve centres, connected each other with inter-central nerve fibres.

EXAMPLES OF REFLEX ACTION—

1. WINKING—

(*a*) Receiving surface=Retina, as from a bright light or cornea, from a particle of dust in the eye

(*b*) Sensory nerve=Optic (for retina) or fifth from cornea

(*c*) Nerve centre=Corpora quadrigemina

(*d*) Motor nerve=The seventh nerve

(*e*) Muscle=Orbicularis palpebrarum

2. VOMITING FROM TICKLING THE FAUCES—

(*a*) Receiving surface=The fauces

(*b*) Sensory nerve=Glasso-pharyngeal and fifth nerves

(*c*) Nerve centre=In the medulla

(*d*) Motor nerve=Phrenics, nerves to abdominal muscles and vagi

(*e*) Muscles=Muscles of extraordinary expiration.

SPINAL NERVES

The spinal cord gives origin in its course to 31 pairs of spinal nerves Each spinal nerve arises by two roots,—(1) *posterior* (2) and *anterior*

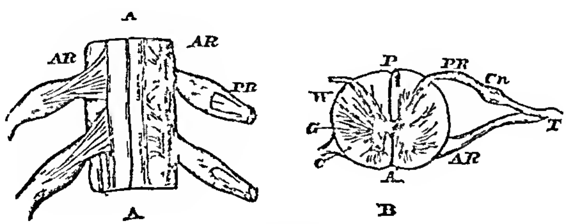


Fig 40 The Spinal Cord

A A front view of a portion of the cord On the right side, the anterior roots, *A R*, are entire, on the left side they are cut, to show the posterior roots, *P R*

B A transverse section of the cord *A*, the anterior fissure, *P* the posterior fissure, *G*, the central canal, *C*, the grey matter, *W*, the white matter, *A R*, the anterior root, *P R*, the posterior root, *Gn*, the ganglion, and *T*, the trunk of a spinal nerve

The posterior is distinguished by its greater thickness, and by presence of *swelling* called "*ganglion*," in which are found numerous bi-polar cells. Beyond the ganglion the two roots unite to form within the spinal canal the mixed trunk of a spinal nerve

The anterior root is motor and the posterior is sensory It was discovered by Sir Charles Bell

1 BY CUTTING—

(1) The *anterior root* motion lost, but sensation unaltered.

(2) The *posterior root* sensation lost, but power of movements remains

(3) *Both roots* sensation and motion both lost.

2 BY STIMULATING—

(1) The peripheral end of cut posterior neither motion nor sign of pain

(2) Central end of cut posterior root signs of pain

(3) Peripheral end of cut anterior root movement in muscles below, but no sign of pain

(4) Central end of cut anterior root no movement in muscles below

SYMPATHETIC NERVE SYSTEM.

Sympathetic nerve system consists of a chain of swellings or ganglia, connected each other by intermediate cords of grey nerve fibres, and extending on each side of the vertebral column, from the base of cranium to the coccyx These chain of sympathetic ganglia, as they pass along the spine, are connected with spinal nerves Each spinal nerve connects each sympathetic ganglian by *Ramus communicons*

FUNCTIONS OF SYMPATHETIC NERVE—

(1) THE VASO-MOTOR FIBRES OF THE HEAD are supplied by the cervical portion of the sympathetic, originating in the cervical region of cord The fibres

supplying the radiating fibres of the iris also come from that region

2 THE VASO-MOTOR OF THE UPPER LIMBS and of the thorax come

(*a*) from inferior cervical and superior thoracic ganglia, and

(*b*) from the cord.

3 THE VASO-MOTOR OF THE LOWER LIMBS come from the cord through the sciatic and crural nerves, whilst those of the pelvic organs are derived from the abdominal ganglia of the sympathetic.

4 THE VASO-MOTOR OF THE ABDOMINAL viscera exist in the splanchnic nerves

5 The splanchnic nerves all arise from the thoracic ganglia of the sympathetic The splanchnic supply the stomach, liver, spleen, pancreas, intestines, and kidneys. They act as vaso-dilator and vaso-constrictor, and also inhibit peristaltic actions of the stomach and intestines They also contain secretory filaments

CRANIAL NERVES

I. THE FIRST OR OLFACTORY NERVE

ANATOMY —It arises from the olfactory bulbs, pass through the ethmoidal plate, and are distributed to the mucous membrane in the upper part of the nose

PHYSIOLOGY —This is only nerve of *smell* "The centre for smell lies in the tip of the *uncinate gyrus* on the inner surface of the cerebral hemisphere"

Paralysis of the nerve causes loss of smell.

II THE SECOND OR OPTIC NERVES —

ANATOMY —The optic nerve takes origin from—

1 Ganglianic centres { Optic thalamus; Corpora geniculata; Corpora quadrigemina.

2 Cortical visual centres, *i.e.*, radiation in the occipital lobes

They consist of *optic tracts* which decussate partially each other to form *Chiasma* The nerves are given from the sides of the chiasma, they pass through the optic foramen, pierce the sclerotic and choroid, and expand into the retina. Each *optic tract* consists of three sets of fibres—

(1) Outer set of fibres go to optic nerve of same side to supply temporal side of the eye

(2) Middle fibres, which decussate with the fibres of the opposite tract, go to form optic nerve of opposite side, supplying the nasal side of the opposite eye.

(3) Fibres have no real connection with vision

PHYSIOLOGY —Nerves of sight, section or degeneration of the nerve causes blindness

LESION AT THE TRACT —Suppose tumour pressing on the left tract, there is blindness of temporal side of the same sido (left) and nasal side of opposite (right).

LESION AT THE COMMISSURE —There is blindness of nasal side of the both eyes

III THE THIRD NERVE OR OCULOMOTOR

ANATOMY—arises from the floor of an aqueduct of sylvian, passes through ligumentum of crus on the inner side, and forwards to be distributed to—

(1) Sphincter pupillæ.
(2) Ciliary muscle.
(3) All the muscles of the eyeball except superior oblique and external rectus It also supplies levator palpebral superioris.

PHYSIOLOGY.—The nerve concerned in accommodation of vision and certain movements of the eyeballs.

PARALYSIS

1 PTOSIS or drooping of upper eyelid

2. Divergent squint

3 Double vision

4. Loss of positive accommodation, as the ciliary muscle is paralysed

5 Paralysis of sphincter of iris—dilatation of pupil.

6 Movements of eye very limited

IV. THE FOURTH NERVE—

ANATOMY—arises from grey nuclei immediately below the origin of the third nerve, and it passes forwards in the outer wall of the cavernous sinus, and enters the superior oblique

PHYSIOLOGY —It is motor nerve of the superior oblique muscle

PARALYSIS —There is slight squinting with diplopia or double vision

THE FIFTH NERVE OR TRIGEMINUS—

ANATOMY —This nerve has two roots—motor and sensory—

(1) THE MOTOR ROOT takes its origin from the floor of the fourth ventricle.

(2) THE SENSORY ROOT arises from cells in the lower part of the medulla, and also from outer wall of the aqueduct of Sylvian, and this root has a ganglion called Gasserian-ganglion The nerve in front of this ganglion divides into three branches—

(1) Ophthalmic

(2) Superior maxillary

(3) Inferior maxillary

PHYSIOLOGY—

1. MOTOR—

(1) Muscles of mastication

(2) Mylo-hyoid and anterior belly of digestric

(3) Tensor tympani.

(4) Tensor palati.

2 SENSORY TO—

Scalp, face, nose, conjunctiva, and iris Cavity of the mouth (except palate), and external auditory meatus

3 SECRETORY TO—

The lachrymal gland

4 TROPHIC TO—

The cornea

Hair roots

PARALYSIS of the whole nerve causes—

1 The paralysis of muscles of mastication mastication is impaired

2. Loss of sensation to parts supplied.

3 Inflammatory changes in the cornea due to—

(*a*) Anæsthesia (irritating particles are not felt, therefore not removed)

(*b*) Atrophic changes

4 Impaired taste in anterior two-thirds of tongue.

THE SIXTH NERVE

ANATOMY—arises from floor of the fourth ventricle runs forward in the wall of the cavernous sinus to the external rectus

PHYSIOLOGY —It is motor nerve to external rectus.

PARALYSIS CAUSES.

Internal squint

THE SEVENTH OR FACIAL NERVE

ANATOMY —The nerve consists of two parts, the facial part (portia dura), and the auditory part (portia mollis) The facial part arises from the floor of fourth ventricle from the facial nucleus It is also connected by motor fibres with the cortex in the fissure of Rolando

PHYSIOLOGY

1 MOTOR TO—

(1) Muscles of expression

(2) Stylo-hyoid

(3) Posterior-belly of digastric
(4) Stapedeus
(5) Platysma

2 SENSORY—

Special sense of taste to anterior two-thirds of tongue.

3 SECRETORY TO—

(1) Sub-maxillary gland } from chorda timpani
(2) Sub-lingual gland }
(3) Glands of mouth and tongue

PARALYSIS CAUSES—

(1) MOTOR CHANGES—BELL'S PARALYSIS—

(*a*) Face drawn to opposite side
(*b*) The wrinkles disappear from the brow.
(*c*) Eye wide open, unwinking
(*d*) Cheek puffs out with expiration
(*e*) One cannot whistle or blow and laugh properly, and angle of mouth is depressed

(2) HEARING IS AFFECTED —There is an increase in sensibility to loud sound, as stapedeus is paralysed

(3) SENSORY CHANGES —Loss of taste in anterior two-thirds of the tongue

(4) SECRETORY CHANGE —The mouth is dry, because the salivary glands are not secreting

EIGHTH OR AUDITORY NERVE

It arises from the floor of the fourth ventricle by two roots for vestibular and cochlear nerves separately The vestibular branch is connected with grey matter of the cerebellum The cochlear branch is connected with superior tempro-sphenoidal lobe

PHYSIOLOGY

This nerve performs two functions—

(1) It is the nerve of hearing

(2) By means of its fibres in connection with the ampulla and semi-circular canals it transmits impulses to the

cerebellum, and thus assists the co-ordinating function in maintaining the equilibrium of the body

PARALYSIS CAUSES total deafness.

NINTH OR GLASSO-PHARYNGEAL NERVE—

ANATOMY —It arises from the floor of the fourth ventricle below the vagus and passes through jugular foramen in separate tube of *dura mater*

PHYSIOLOGY

MOTOR TO—

Stylo-pharyngeus and constrictors.

SENSORY TO—

Posterior third of the tongue, the anterior surface of the epiglottis, the tonsils, anterior pillars of fauces and soft palate

It is the nerve of taste for the posterior third of tongue

SECRETORY TO—

Parotid gland

PARALYSIS CAUSES—

1 Loss of taste and sensation to parts supplied by the nerve

2 Diglutition is impaired

3 Parotid nerve of secretion is paralysed.

TENTH OR PNEMOGASTRIC OR VAGUS NERVE—

ANATOMY—Arises from floor of the fourth ventricle It is the longest cranial nerve It passes across the flocculus to the posterior part of the jugular foramen, and passing through, it is then joined by the inner division of the spinal accessory nerve It has two ganglia—

(1) Ganglion in the jugular foramen

(2) Ganglion, just below the foramen

The nerve gives out in its course branches which contain fibres to subserve different functions

THE BRANCHES OF DISTRIBUTION ARE—

(1) AURICULAR BRANCH (Arnold's nerve)—sensory to skin behind auricle

(2) PHARYNGEAL BRANCH—Motor to the muscles of pharynx

(3) SUPERIOR LARYNGEAL——

(1) EXTERNAL LARYNGEAL—Motor to crico-thyroid

(2) INTERNAL BRANCH—Sensory to the mucous membrane of the larynx

(4) INFERIOR OR RECURRENT LARYNGEAL—Motor to all the intrinsic muscles of the larynx, except the crico-thyroid

(5) CARDIAC BRANCHES—

(1) Superior—

(*a*) Sensory to heart.

(*b*) Vaso-inhibitory to the blood-vessels of abdomen (depressor nerve).

(2) Inferior—

Inhibitory to nerve of heart

(6) PULMONARY BRANCHES—

Sensory for the lungs, and excito-motor for inspiration

(7) ŒSOPHAGEAL BRANCHES—Motor to the muscle and sensory to the mucous membrane of the œsophagus

(8) GASTRIC BRANCHES—Motor to the muscle and sensory to the mucous membrane of stomach

(9) Left vagus sends sensory branches to the spleen and liver

HOW TO REMEMBER THESE DIFFERENT BRANCHES —

A	=AURICULAR branch
PRODIGAL	=PHARYNGEAL branches
SON	=SUPERIOR laryngeal

RUNS	=RECURRENT laryngeal
CLEVERLY THROUGH A	=CARDIAC branches
PURSE	=PULMONARY branches
OF	=ŒSOPHAGEAL branches
GOLD AND	=GASTRIC branches
SPOILS HIS	=SPLENIC branches.
LIVER	=Branches to liver.

PHYSIOLOGY—

I CENTRIFUGAL FIBRES—

1. MOTOR FIBRES—

(1) To the muscles of the pharynx

(2) To the muscles of the larynx

(3) To the œsophagus

(4) To the stomach

(5) To the small and large intestines, and to the uterus—according to some authorities.

2 REGULATING FIBRES—

Inhibiting fibres for the heart

3 SECRETORY FIBRES—

(1) To the gastric glands

(2) To the kidneys—for irritation of the vagus is said to increase the secretion of urine (*Bernard*)

II CENTRIPETAL FIBRES—

1 SENSORY FIBRES—

(1) To the back of the external ear

(2) To the whole respiratory tract

(3) To the digestive apparatus

(4) To the heart

2 REGULATING FIBRES—

(1) Accelerating fibres for the respiratory centre.

(2) Inhibitory fibres for the same centre.

(3) Vaso-inhibitory for blood-vessels of abdomen (depressor)

(4) Stimulant to glycogenic functions of liver.

THE RESULT OF DIVISION OF BOTH VAGI AT THE MIDDLE OF THE NECK—

I ON THE ALIMENTARY CANAL—

(1) Paralysis of œsophagus, and therefore diglutition is impaired

(2) Paralysis of stomach

(3) Stoppage of gastric juice for the time

II ON VASCULAR SYSTEM—

(1) Heart beats more rapidly

(2) Rise of blood pressure

III. ON RESPIRATORY SYSTEM—

(1) Paralysis of the laryngeal muscles, and vocal cords, and therefore loss of voice, and passage of food into the lungs, causing pneumonia

(2) Respiration is slowed and deepened

IV Stoppage of the reflex actions, which usually occur on stimulation of the mucous membranes of the larynx, pharynx, and stomach

SUMMARY OF THE FUNCTIONS OF THE VAGUS—

1 Sensory to pharynx, larynx, heart, root of tongue, œsophagus, stomach, spleen, liver, external auditory meatus, and auricle

2 MOTOR to larynx, bronchi, pharynx, œsophagus, and cardiac end of stomach

3 Inhibitory of heart

4 Secretory—for glands of stomach

ELEVENTH OR SPINAL ACCESSORY NERVE—

ANATOMY —This nerve arises by two roots One accessory root takes its origin from the nucleus of the medulla oblongata, while the spinal root arises from spinal cord between anterior and posterior nerve-roots, as low as the fifth or sixth cervical vertebra

PHYSIOLOGY—

1 THE SPINAL ROOT is motor to the sterno-mastoid and trapezeus.

2 THE ACCESSORY ROOT joins the vagus, forming its motor root this part contains the inhibitory nerve of the heart, as well as the motor nerves for the larynx and pharynx

RESULTS OF DIVIDING THIS NERVE—

1 SPINAL ROOT—

Paralysis of the sterno-mastoid and trapezeus.

2 ACCESSORY ROOT—

(1) Heart beats more rapidly
(2) Loss of voice
(3) Swallowing is impaired

TWELFTH OR HYPO-GLOSSAL NERVE—

ANATOMY—arises from the nucleus at lowest point of fourth ventricle

PHYSIOLOGY—

It is motor to extrinsic and intrinsic muscles of tongue.

PARALYSIS CAUSES—

If bilateral paralysis causes complete paralysis of tongue, the tongue cannot protrude or retract.

THE CENTRAL NERVOUS SYSTEM

The central nervous system is the most important which constitutes the cerebro-spinal nervous axis This is lodged in the cranial cavity and spinal canal respectively

The term "CENTRAL" means mere collection of nerve-cells which are so connected with each other as to subserve combined function These cells communicate each other by branching processes, through which nerve mpulses travel from one to another The nerve-cells and the nerve fibres together constitute NERVE-CENTRES The nerve-cells *originate* impulses, while nerve-fibres chiefly *conduct* nerve-impulses

THE NERVE-CENTRES have power of discharging the following properties —

(1) Reflex activities
(2) Automatic activities
(3) Trophic activities
(4) Inhibitory activities
(5) Psychical activities

These various properties are distributed over different centres The central organs of nervous system consist of ganglia (aggregate of cells) or what is called a " CEREBRO-SPINAL AXIS " The cerebro-spinal axis consists of the *spinal cord, medulla oblongata, pons veroli, basal ganglia, cerebellum,* and the *cerebrum*

THE SPINAL CORD

The spinal cord is lodged in the spinal canal, extending from the foramen magnum to the lower border of the first lower vertebra Above the cord is continuous with medulla oblongata, and below, it ends into the *filum terminale,* which is in the midst of bundles of nerve roots called "*Couda equina*" It gives origin to 31 pairs of spinal nerves Further the spinal cord in its whole length is covered by the following membranes—

1 DURA MATER—This is external covering It is tough fibro-serous vascular membrane lining the spinal canal and forming protective coat of the cord

2 ARACHNOID —It is very delicate non-vascular membrane Placed between the dura and pia, it divides the space between them into two sub-dural space, and sub-arachnoid space The sub-arachnoid space contains most of the cerebro-spinal fluid.

3 PIA MATER —It is a delicate, highly vascular membrane, and firmly adherent to the spinal cord, so that it cannot be easily stripped off A fold passes from it into the anterior median fissure of the cord

THE SPINAL CORD consists of two halves separated anteriorly and posteriorly by *fissure* It is composed of *grey matter* internally surrounded by *white matter* externally

THE GREY MATTER consists of two semi-lunar crescent-shaped)-(masses placed back to back The two crescents are united to each other by the grey commissure, thus giving a resemblance to the capital letter H The extremities of the crescent are known as the *anterior* and *posterior horns* or *cornua* The anterior is *short* and *thick*, the posterior is *long* and *narrow* The grey commissure which connects the two crescents across the middle line has a *central canal*

THE CENTRAL CANAL runs throughout its entire length This canal opens into the space called the fourth ventricle. It is lined by ciliated cylindrical epithelium, and it contains fluid *called cerebro-spinal* fluid The canal is the remains of the nural canal of the embryo The part of grey commissure in front of the canal is *anterior grey commissure*, and the part behind is the *posterior grey commissure*

THE WHITE MATTER surrounds the grey matter giving opaque and white appearance to the cord The white matter, composed of nerve-fibres, forms a series of strand or column The columns are arranged *anterior*, *lateral*, and *posterior*

FISSURES OF THE CORD

1 ANTERIOR MEDIAN FISSURE —It is more distinct than posterior At the bottom of this fissure is a transverse band of white matter, connecting two *haves* of the cord, and is called " the anterior or *white commissure* "

2 POSTERIOR MEDIAN FISSURE —This is not real fissure, it is simply septum

Besides these two chief fissures, we have the *antero-lateral* and *postero-lateral grooves*, indicating the lines of origin of the anterior and posterior nerve roots The anterior root takes origin from antero-lateral groove, while posterior

root of same from postero-lateral groove a pair of roots on each side corresponds to each vertebra

THE APPEARANCE OF THE GREY MATTER AT DIFFERENT REGIONS OF CORD

1 In the *cervical* region the anterior horn is broad and thick, the posterior long and narrow

2 In the *dorsal* region they are both narrow, closely resembling the capital letter H

3 In the *lumbar* region, they are both broad and thick, and do not reach to the surface.

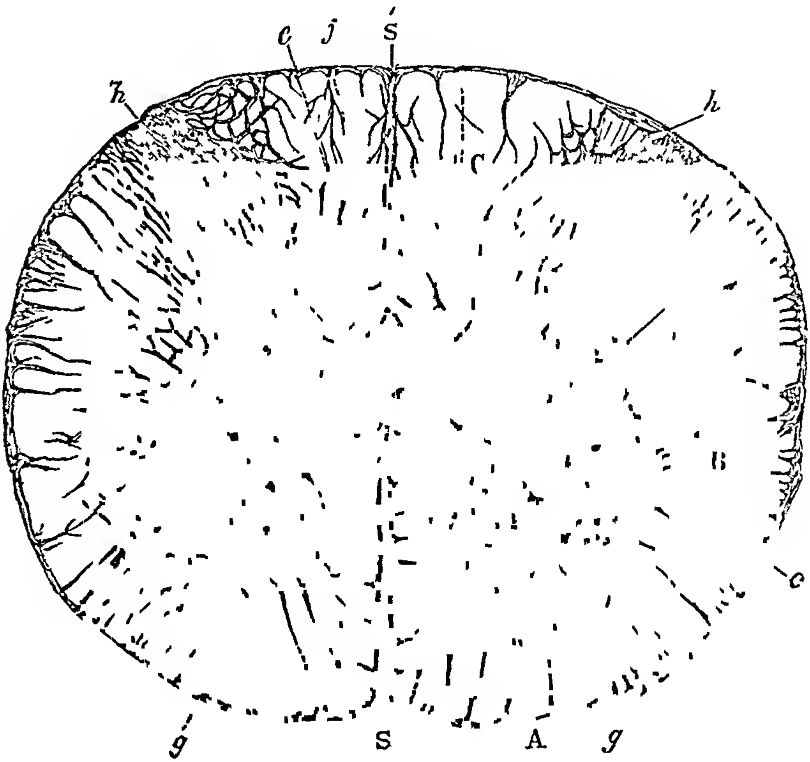


Fig 41 SECTION OF THE SPINAL CORD IN THE CERVICAL REGION

A, anterior, B, lateral, and C, posterior columns, S, anterior and s′ posterior median fissures, *a*, *b*, c, cells of anterior cornu, *c*, central canal, *g*, anterior root bundles, *h*, posterior root-bundles, *i*, white commissure, *j*, grey commissure

THE STRUCTURAL ELEMENTS OF THE GREY MATTER

The grey matter is composed of—

I Nervous elements—*Cells* and *fibres*

II Connective tissue—*Neuroglia*

I NERVOUS ELEMENTS are—

NERVE CELLS —The cells are multipolar cells, singly or in groups with *processes*—

THE PROCESSES ARE —

(*a*) AN AXIAL CYLINDER process, which does not branch but becomes directly continuous with a nerve fibre

(*b*) PROTOPLASMIC PROCESSES that branch and form a fine dense network of fibrillæ in the grey matter

The cells are largest, and arranged in groups in the anterior horn of the grey matter being related to motor root

ARRANGEMENT OF NERVE-CELLS —The nerve-cells are arranged in definite groups, forming *vesicular columns* of the grey matter, as follows —

(*a*) ANTERIOR VESICULAR COLUMN —The cells found along the whole of the anterior part of the horn The cells are largest and arranged in an outer and an inner group of cells In function the cells are *motor* and *trophic*

(*b*) INTERMEDIO-LATERAL VESICULAR COLUMN.—The cells being arranged in groups, situated in the projection of grey matter about midway between the anterior and posterior horns best seen in the dorsal region

(*c*) POSTERIOR VESICULAR COLUMN (CLARKE'S COLUMN) —The cells being arranged singly are found at the base of the posterior This column is well marked in the middle of cord from third lumbar to seventh cervical nerve

NERVE-FIBRES.—The grey matter contains plexus of the finest nerve fibrils called *Gerlach's network*, mingled with neuroglia These fibrils are produced by repeated sub-division of *protoplasmic processes* of multi-polar cells Many medullated nerve-fibres divide and become non-medullated. Fibres pass from the grey matter of one side to that of the other through the commissure in front of and behind the central canal

II NEUROGLIA.—The connective tissue of the grey matter is composed of a kind of semi-fluid matrix with processes. It is arranged as sponge-work to support nerve-cells It is specially well marked around the central canal.

THE WHITE MATTER OF THE CORD

The external white part of the cord consists of nerve fibres, with a supporting reticular framework of connective tissue and blood-vessels derived from the pia mater The fibres are medullated without the sheath of Schwan and arranged longitudinally The fibres are arranged into *anterior, lateral, and posterior* columns Each of these columns is divided into the following *tracts* —

I. ANTERIOR COLUMN—

1. ANTERO-INTERNAL TRACT or column of Turk or direct, or uncrossed, pyramidal tract. It is called *direct pyramidal* tract, because it does not decussate in the bulb, and external to this is

2. ANTERO-EXTERNAL tract or basis bundle of Turner or anterior root zone of Charcot

II LATERAL COLUMN—

1. ANTERO-LATERAL TRACT or sensory zone of Gowers.

2. LATERAL LIMITING TRACT or mixed zone

3 DIRECT CEREBELLAR TRACT—This connects the cord with cerebellum, and its fibres arise in the cells of Clarke's column

4 CROSSED PYRAMIDAL TRACT.—This lies external to the posterior half of the grey matter

5 Comma tract of Gowers

III POSTERIOR COLUMN—

1 POSTERO-INTERNAL tract or Goll's column

2 POSTERO-EXTERNAL tract or Burdoch's column or fasciculus cuneatus or posterior root zone of Charcot

OFFICE OF DIFFERENT TRACTS.

The tracts are conducting paths in the spinal cord. The conducting paths are ascertained by the effects of *injuries* and *disease* The trophic or nutritive centres for the descending (motor) fibres are situated in the cerebrum, and for the ascending (sensory) fibres are situated in the spinal ganglia of the posterior nerve roots When the conducting paths are *separated* from their *trophic centres* (by section, or by disease), *degeneration* results, (Wallerian law of degeneration) and by tracing the degenerated areas we map out the columns into *tracts*

THE MOTOR TRACTS ARE—

(1) Crossed pyramidal tracts

(2) Direct pyramidal tract

THE SENSORY TRACTS ARE—

1. Postero-internal (Goll's)

2 Postero-external or Burdoch's

3 Comma tract of Gowers

DIRECT CEREBELLAR TRACT is concerned with co-ordination of the muscular movements

TROPHIC CENTRES OF CONDUCTING PATHS.—The trophic centre for *motor tracts* lies in the cerebrum termed first *Trophic realm* A lesion in the certain part of cerebrum causes a secondary degeneration of certain parts of the cord The white matter of definite areas of the cord degenerate downwards termed *Descending degeneration*

THE TRACTS WHICH UNDERGO *Descending Degeneration* ARE—

(1) The crossed pyramidal tract

(2) The direct pyramidal tract

(3) The antero-lateral descending tract

(4) The descending comma tract

THE TROPHIC CENTRE for the fibres of the *anterior root* lies in the multipolar nerve-cells of the anterior horn of the grey matter of the cord Any interference with the multipolar nerve-cells causes *degeneration* of motor nerves, thus *wasting* of the muscles, and there is liability to the formation of bed-sores

THE TROPHIC CENTRE FOR SENSORY AREA lies on the *posterior root* of the spinal nerve (Gasserian ganglion) The lesion in the cord causes *ascending degeneration, i e*, the certain portion of the cord degenerates upwards

THE TRACTS WHICH UNDERGO *ascending degeneration* ARE—

(1) Postero-internal or Goll's

(2) Direct cerebellar tract

(3) Antero lateral tract

The areas which do not degenerate in disease or after section of cord is believed to be *commissural* in function, *i e*, connect ganglionic cells with each other Therefore they are provided with trophic centre at both ends

FUNCTIONS OF THE SPINAL CORD

I An originator of spinal nerves by two roots—*anterior* and *posterior*

II A conductor of impression to and from the brain

III A great reflex centre

I ORIGINATOR OF SPINAL NERVE—

The anterior and posterior roots of the spinal nerves are attached along the sides of the cord, opposite to the corresponding horns of the grey matter

ANTERIOR ROOT—

The fibres of the anterior root may be traced—

(1) Some of the fibres end in nerve-cells in the anterior horn

(2) Some of the fibres pass through the grey matter and cross to the other side of the cord through the anterior commissure

(3) Some of the fibres pass in the lateral column, and to the posterior horn

POSTERIOR ROOT—

The fibres of the posterior root are in *two bundles, external* and *internal.*

The fibres of the *external* bundle may be traced to—

(1) The nerve cells of the posterior horn.

(2) The anterior horn.

(3) The posterior part of the commissure

The fibres of the *internal* bundle do not pass straight to the grey matter, but enter the white substance of the posterior column, and ultimately pass to—

(1) The lateral cells of anterior horn

(2) The cells of Clarke's column

(3) The posterior part of the commissure (*Vide* Fig 42)

II CONDUCTION OF IMPULSES TO AND FROM THE BRAIN—

PATHS OF CONDUCTION OF MOTOR IMPULSES

The motor impulses arising from cerebral cortex pass downward In the medulla most of the fibres *cross* (decussate) to *opposite* side, and pass down the cord as the *crossed pyramidal tract,* but a certain number pass downwards for some distance on the same side as that from which the paths originally rose from the *direct pyramidal*

tract, then the fibres pass to the *multipolar cells* of the anterior horn of grey matter, and finally out by the anterior motor root (see green part of diagram 42)

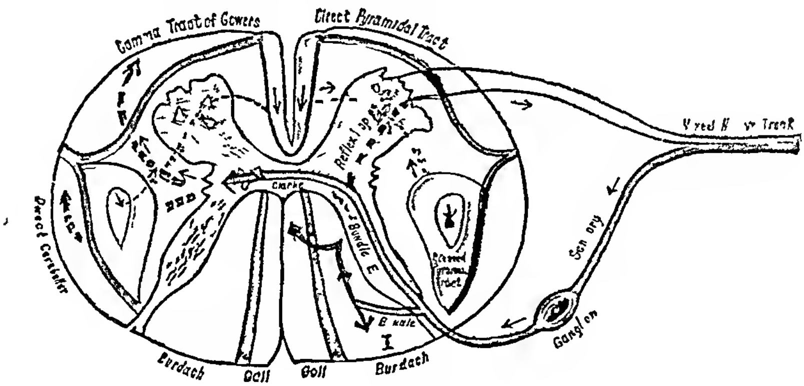


Fig 42

A diagram, to show the course of the motor fibres (*green*) and the sensory fibres (*red*)

Note the motor fibres pass from the *direct* and *crossed* pyramidal tracts to the anterior horn of grey matter and thence to the anterior nerve root

These sensory fibres pass in, in two bundles, E and I (after Wheeler modified)

PATHS OF CONDUCTION OF SENSORY IMPULSES

SENSORY IMPULSES—

The sensory impulses arise from end-organs The impulses run from the *periphery* to the *centres* in the mixed nerves until they enter the spinal cord by the *posterior roots* The sensory fibres enter the grey matter in two bundles, *i e*, bundle E and bundle I.

BUNDLE E passes first into column of Burdoch, descends and ascends a little, then enters the column of Goll, passes straight up to the medulla, and there decussates to the opposite side.

BUNDLE I passes into the grey matter A few fibres go to the anterior horn to form, with the motor cells, a complete *reflex loop* The bulk of the fibres, however, cross to the column of Clarke, and thence to direct cerebellar and comma tract of Gowers. (Follow diagram 42)

EXPERIMENTS TO SHOW THE CONDUCTING PATHS OF THE CORD.

1 Cut through lateral half at *any* part, and there is—

(*a*) Loss of motion, but *increase* of sensibility—except tactile sensation which is said to be lost (Schiff) on the *same side below* the injury.

(*b*) Loss of sensation, but motion not affected on the *opposite* side below the injury.

2 Make a vertical median incision in the cord at any part there is loss of sensibility on both sides in a part corresponding to the length and position of the incision Voluntary movement not affected

3 Make a vertical median incision at decussation (in medulla) there is loss of motion on both sides

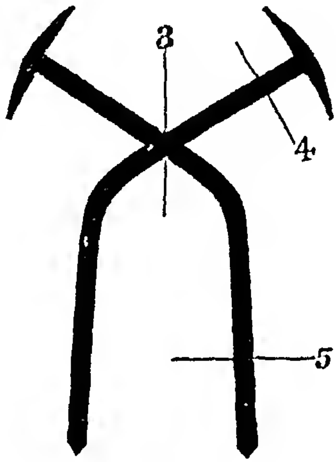


Fig 43

4 Cut through right *crus cerebri*—or, what is the same thing, suppose there be a *blood clot* on the right side of the brain involving both motor and sensory areas. There is loss of both motion and sensation on the left, *i e.*, the opposite side

5 Cut through all the white columns entirely, leaving only the grey matter, or any part of it—sensation that give rise to pain are still felt

INFERENCE DRAWN FROM THESE EXPERIMENTS ARE —

(1) Motor impulses start in the brain, cross to the other side at the upper part of the medulla, and descend in the antero-lateral column, keeping to the same side throughout

(2) SENSORY IMPULSES pass from the posterior root along a certain length of the posterior column, then cross to the other side and ascend to the brain

(3) TACTILE SENSORY impression also pass up the posterior column of the same side (Schiff), though others believe that they decussate in the spinal cord

(4) SENSATION THAT GIVE rise to pain pass up through all parts of the grey matter, probably decussating in the cord

(5) SENSATION OF TEMPERATURE are probably conducted along a separate and distinct set of fibres, and undergo distinct set of fibres, and undergo decussation in the cord

(6) VASO-MOTOR fibres pass along the lateral columns, and leave by the anterior nerve roots

(7) CO-ORDINATING fibres from the cerebellum are probably in the direct cerebellar tract

III A GREAT REFLEX CENTRE

REFLEX CENTRES IN THE SPINAL CORD ARE —

1 THE CILIO-SPINAL CENTRE for the dilatation of the pupil lies in the lower cervical part of the cord

2 Vasa-motor and vaso-dilator centres are situated all through the spinal cord

3 THE SWEAT CENTRE for secretion of sweat lies all through the cord

4 THE ANO-SPINAL CENTRE for the act of defæcation lies in the lumbar region at the fifth to seventh lumbar vertebra

5 THE VESICO-SPINAL CENTRE for the act of micturition lies at the fifth or seventh lumbar vertebra

6 THE CENTRES FOR THE ORGAN OF GENERATION are placed in the lumbar region—

(*a*) THE ERECTION CENTRE lies in the lumbar region

(*b*) THE EJACULATION CENTRE for emission of semen lies at the fourth lumbar vertebra

(*c*) THE PARTURITION CENTRE lies at the first and second lumbar vertebræ

These centres, though capable of discharging reflex act, are under the *control* of higher function of the brain

If the cord be cut or crushed at the lower part, the centres placed there are paralyzed—the fæces pass involuntarily, and the urine is either retained or dribbles away constantly

REFLEX ACTION —By the term reflex movement means that a movement is resulted by stimulation of *afferent* (sensory) nerve Therefore three factors are concerned for bringing about such movement—

(*a*) Afferent nerve.
(*b*) Transforming centre.
(c) Efferent nerve

These together constitute a *reflex loop* A break in any part of this loop must be attended with loss of reflex

INHIBITION OF REFLEX ACTIONS —The reflex action of the spinal cord may be inhibited or restrained The brain exercises an inhibitive action, if the cord be cut off from its inhibitive influence, reflexes must be exaggerated.

THE REFLEXES are classified in three groups, viz —

(1) The superficial
(2) The deep or tendon reflex
(3) The organic reflexes

THE SUPERFICIAL REFLEXES ARE—

The plantar, gluteal, cremastric, abdominal and epigastric

They are excited by scratching or tickling or pricking the cutaneous surfaces in these regions

THE DEEP REFLEXES are the *knee-jerk* and *ankle-clonus*

THE KNEE-JERK is elicited—cross the legs, and strike the tendon of the patella sharply, the foot is jerked upwards

ANKLE-CLONUS —It is not present in health. This is elicited by extending the leg and applying the pressure upon the sole of the foot so as to flex the foot at the ankle, a series of contraction of calf of muscles takes place

The ankle-clonus is not found in healthy conditions, but the knee-jerk is present in all healthy persons, and

its extent varies in pathological conditions It may be increased or decreased

AN INCREASE OF THE KNEE-JERK indicates irritability of the grey matter of the cord or of diminution of inhibitory influence of higher centres

A DECREASE OF THE KNEE-JERK INDICATES interference in the reflex loop

THE ORGANIC REFLEXES are acts of micturition, erection, ejaculation, defæcation, &c

The drugs influence the activity of the reflex act

Strychnia Alkaloids of opium	Increase the reflex activity
Aconite Hydrocyanic acid Ether Chloral Chloroform	Decrease the reflex activity

THE BRAIN

The brain is a complex organ, including all parts of the great central nervous system enclosed within the cranium, viz —

(1) The cerebrum
(2) The basal ganglia
(3) The cerebellum
(4) The pons varolii
(5) The medulla oblongata

Inside the brain is cavity which is continuation of the central canal of the spinal cord The cavity is filled with cerebro-spinal fluid, and lined by ciliated epithelium The cavity is enlarged at certain places called *ventricles*

THE MEDULLA OBLONGATA

This is the prolongation into the cranium of the spinal cord so as to unite it with the brain It is continuous below with the spinal cord, and above with the pons Varolii The following table shows the connection of the cord and of the medulla with the rest of the brain

The Fibres of white tracts of the Cord traced up through the Medulla.

Cord		Medulla	Pass on to
Anterior column	1. Direct pyramidal tract	To anterior pyramid of same side	Cerebrum.
	2 Mixed zone	To posterior longitudinal bundle To olivary peduncle and *fillet* To formatio reticularis	
Lateral column.	1. Crossed pyramidal tract .	To anterior pyramid opposite side or *decussation of the pyramids*	Cerebrum.
	2 Direct cerebellar tract .	To restiform body	Cerebellum.
	3. Mixed zone	To olivary fillet To formatio reticularis. To fasciculus teres (Turner).	
Posterior column	Postero-internal, galls	To funiculus gracillis, which with the expansion called the clava	Cerebrum.
	Postero-external	To funiculus cuneatus To formatio reticularis	Cerebellum

DECUSSATION OF THE PYRAMIDS —This term is given to those fibres which cross at the lower part of the medulla from anterior pyramid of medulla to crossed pyramidal tract of the cord. Medulla is the chief situation where decussation to take place

THE GREY MATTER OF THE MEDULLA—

The grey matter is divided into—

I That which are independent masses of grey matter.

II That which are derived from the grey matter of the cord

I THE INDEPENDENT MASSES OF GREY MATTER ARE —

(1) Nucleus of the olivary body

(2) The accessory olivary nuclei.

(3) Corpus dentatum

II THE GREY MATTER DERIVED FROM THE GREY MATTER OF THE CORD ARE —

1 FROM THE ANTERIOR HORN we find—

(a) From its head, the *nucleus lateralis*

(b) From its neck, *the anterior part of the formatio reticularis*

(c) From its base, the *nucleus of the fasciculus teres*

2 FROM THE POSTERIOR HORN—

(a) From its head, the *nucleus of Rolando.*

(b) From its neck, *the posterior part of the formatio reticularis.*

(c) From its base, nucleus of the funiculus gracillis, nucleus cuneatus, and nuclei on the floor of the 4th ventricle

THE NUCLEI OF THE FOLLOWING CRANIAL NERVES ARE FOUND IN MEDULLA —

1 The *hypoglossal* nucleus for hypoglossal nerve

2 Common nucleus, for a portion of the *spinal accessory*, *vagus* and *glosso-pharyngeal* nerves

3 Auditory nucleus for *auditory nerve*

4 Nuclei for the *sixth* nerve

5. Nucleus for the *fourth* nerve

6 Nucleus for the *facial* nerve

FUNCTIONS OF MEDULLA OBLONGATA.

1 A conductor of motor and sensory impression like cord The motor fibres coming from the brain decussate in the anterior pyramids, and then run down the lateral column of the cord, supplying the muscles by the anterior roots of spinal nerves Hence, whilst the section of an antero-lateral column of the cord will cause paralysis of motion on the same side, section of an anterior pyramid above the decussation causes paralysis of motion of opposite side

2 A GREAT CENTRE FOR THE REFLEX

Numerous special centres are found in medulla, viz —

(1) Centre for *sucking* and mastication

(2) Centre for *swallowing*

(3) Centre for the secretion of *saliva.*

(4) Centre for *respiration* are two, viz —

(*a*) Inspiratory

(*b*) Expiratory

(5) The medulla assists the co-ordination of spinal reflex movements

(6) Centre for *vomiting*

(7) Centre for *dilator pupillæ*

(8) Centre for closure of the *eyelids.*

(9) Centre for the inhibitory nerves of the heart (cardio-inhibitory)

(10) Centre for the accelerator (nerves-accelerons)

(11) Centre for sweat

(12) Centre for *vaso-motor* nerves for regulating the calibre of the smaller blood vessels throughout the body.

HOW TO REMEMBER THESE CENTRES?

Suck, swallow, salivate,
Respirate, co-ordinate
Think of the *vomiting* centre try,
Dilate the pupil, wink the eye
Heart from *slow* to *quick* may range,
Producing *sweat* from *vaso-motor* change

The medulla oblongata is an extremely important part of the cerebro-spinal axis, injury to it giving rise to immediate evil consequences of the most serious kind Simple puncture of one side of the floor of the fourth ventricle produces excess of sugar in the blood

PONS VAROLII

The pons Varolii is above and in front of the medulla, and between the hemispheres of cerebullum It consists of fibres passing in two directions, viz —

LONGITUDINAL fibres connect the brain above with the medulla and cord below

TRANSVERSE fibres connect the lateral hemispheres of the cerebullum

THE FOLLOWING NUCLEI ARE FOUND —

(1) The nucleus of the *facial* nerve
(2) The motor nucleus of the fifth nerve
(3) The upper sensory nucleus of the *fifth* nerve.
(4) The chief nucleus of the *auditory* nerve
(5) The nucleus of the *sixth* nerve

The fibres of the facial nerve decussate in the pons. Injury or disease of the pons may cause paralysis of the face on the same side as the disease Pons also are regarded as conductor of impression as medulla and cord

CEREBELLUM

It is important to note the connection of cerebellum with rest of cerebro-spinal axis. It has three peduncles, viz. —

(1) THE SUPERIOR PEDUNCLES or *crura ad cerebrum*, it connects the cerebellum to the cerebrum.

(2) THE INFERIOR PEDUNCLES or *crura ad medullum*, formed by the restiform bodies, and bounded by the lower lateral part of the fourth ventricle

(3) THE MIDDLE PEDUNCLES or *crura ad pontum*, they form much of the transverse fibres of the pons

THE GREY MATTER OF THE CEREBELLUM

On the cortex it covers the surface and also lines the sides, and passes across the bottom of its various fissures and *sulci*, so that it is like a thin lamina folded on itself in a series of leaves On vertical mesial section, it shows a tree like appearance The principal grey mass in the *interior* is called the *Corpus dentatum*

THE STRUCTURE OF THE GREY MATTER—

1 THE OUTER MOLECULAR LAYER consists of *neuroglia, nerve cells,* and *fibres*

2 THE INNER GRANULAR LAYER consists of nucleated corpuscles closely packed together

3 THE MIDDLE LAYER is formed by the *cells of purkinji* ("antler cells")

These are large flask-shaped cells set at right angles to the surface of the cerebellum Their central end gives off a single unbranched process, the outer end gives off a large process that branches like the horns of a deer, sending fine processes up to the outer layer of the cortex

FUNCTIONS OF THE CEREBELLUM—

1 It is probably a centre for the *co-ordination* of muscular movements, such as walking

2 It is also concerned in *equilibration*

RESULT OF EXPERIMENT ON CEREBELLUM —If the cerebellum be removed gradually by successive slices—in pigeon—there is progressive effect on *locomotion* It is observed on making successive slices of cerebellum that

when the sections have reached the middle of the organ, the animal staggers much, and still further down animal cannot keep up its own equilibrium At last when the entire cerebellum is removed, the animal cannot support itself

Co-ordination means the harmonious action of muscles involved in the carrying out of complicated movements This is maintained by the centres to act through afferent impressions derived from—

(1) The sense of touch (Goll and Burdoch tracts)

(2) Sight (optic nerves)

(3) Auditory organs (semi-circular canals)

(4) The muscular sense

BASAL GANGLIA

They are masses of grey matter overlapped by the cerebral hemispheres

These ganglia include—

(1) The corpora quadrigemina

(2) The optic thalmi

(3) The corpora striata

(4) The corpora geniculata

(5) The locus nigur

THE CORPORA QUADRIGEMINA—

These are two pairs of rounded tubercles placed on each side of middle line above the aqueduct of Sylvius, which passes between the third and fourth ventricles They are situated behind the optic thalmi

FUNCTION—

These bodies are the centres of the reflex movements of the iris and of the ciliary muscle

OPTIC THALMI—

These are two large oval ganglionic masses placed in front of the corpora quadrigemina and behind the corpora striata

CORPORA STRIATA—

These ganglia are situated in front and on the outer side of the optic thalami Each corpus consists of two parts, viz —

1 THE NUCLEUS CAUDATUS or intra-ventricular nucleus, it is seen into the lateral ventricle

2 THE NUCLEUS LENTICULARIS or extra-ventricular nucleus, it is embedded in the white substance of the cerebral hemisphere It is separated from the caudate nucleus by a strand of white fibres, called "*Internal capsule,*" whilst on the outer side there is another strand of white fibres called "*External capsule,*" beyond which, again, is a lamina of grey matter called the "*Claustrum*"

FUNCTION—

Corpus striatum is a centre for the co-ordination of motor impulses, it usually acts in obedience to impulses coming from the cerebral hemispheres

CEREBRAL PEDUNCLES OR *Cruri Cerebri*—

These are two thick strands of fibres containing sensory and motor They establish a connexion between the cerebellum and the cerebrum, and also between ganglia at the base The crus is divided by the *locus niger* into the *crusta, pes,* and *tegmentum*

THE CRUSTA OR PES is composed of sensory and motor fibres, which can be traced from the cerebrum to the pons, medulla, and spinal cord

THE TEGMENTUM in addition to many nerve fibres contains grey matter with nerve hyphen-cells Above the tegmentum is the origin of the third nerve Outside tegmentum is fillet

THE FILLET arises from medulla and joins the tegmentum

FUNCTION OF THE CRURI CEREBRI—

They are conductors of impressions As injury to one cerebral peduncle causes paralysis of the *opposite side*, and paralysis of third nerve same side

ARRANGEMENT OF FIBRES IN THE CEREBRO-SPINAL SYSTEM —

There are —

1 PROJECTION SYSTEM—

(1) CEREBRAL PART, or proximal projection system —fibres from the basal ganglia are spread out into the convolutions of cerebral hemispheres, forming *corona radiata*

(2) MIDDLE PROJECTION SYSTEM—fibres from basal ganglia to pons and medulla This *system decussates*

(3) DISTAL PROJECTION SYSTEM—nerves through the body generally from spinal cord

2 TRANSVERSE COMMISSURAL SYSTEM —These connect the two hemispheres, viz. —

(1) Corpus collosum

(2) Anterior commissure

(3) Middle commissure

(4) Posterior commissure

3 ASSOCIATION SYSTEM—

These are found in each half of the brain, and connect various parts of the same side together, viz —

(1) Fornix

(2) Striæ longitudinales

(3) Tænia semi-circularis

(4) Fibres of gyrus fornicatus

(5) Fibres of uncinate convolution, connecting frontal and tempro-sphenoidal lobes

(6) Longitudinal inferior fasciculus, between occipital and temporal lobe

INTERNAL CAPSULE

It is a narrow band of white fibres close to the base of the brain, just above the crura The narrow piece of white matter between the claustrum and the lenticular nucleus is called the *external capsule* whose function is unknown The internal capsule is formed by the fibres of the *corona radiata* (fan-like spreading) coming from or going to the grey matter of the cerebral cortex It is one of the most important parts of brain for the student of medicine I shall dwell upon it in detail. It consists of the following parts, viz —

(1) THE ANTERIOR SEGMENT lies between the *cordinate nucleus* and *lenticular nucleus*.

(2) THE POSTERIOR SEGMENT—which lies between the *optic thalamus* and the *lenticular nucleus*.

(3) A KNEE, or genu connecting the two segments

FUNCTIONS OF INTERNAL CAPSULE

The *anterior segment* is probably concerned with the *psychological* functions of the brain

THE POSTERIOR SEGMENT OF THE CAPSULE

1 The *anterior third* is *motor* for the *arm* and *hand*
2 The *middle third* is *motor* for the *leg* and *trunk*.
3 The *posterior third* of the segment is sensory
4 The *knee* is *motor* for *the face*

These fibres spread out like fan and are distributed to the cortex, the motor fibres pass to the motor area around the Fissure of Rolando, the sensory fibres to the same area and also to the area which is associated with special sensation

THE CEREBRUM

The short anatomical facts are pointed out here in order to assist in explaining the functions of the organ.

FISSURES OF THE CEREBRUM

V 1 Primary fissures are—

(1) Fissure of Sylvius

(2) Fissure of Rolando

(3) Parieto-occipital fissure

2 SECONDARY FISSURES

These are nerve indentations of the cerebral cortex, and separate the individual convolution from each other By means of these fissures the cerebrum is divided into four lobes

THE LOBES OF THE CEREBRUM

(1) Frontal

(2) Parietal

(3) Occipital

(4) Tempro-sphenoidal

(5) Island of Reil

BOUNDARIES OF THE FRONTAL LOBE

Behind—the fissure of Rolando

Below—the horizontal limb of the sylvian fissure

Above—the great horizontal fissure

CONVOLUTIONS OF THE FRONTAL LOBE

(1) Ascending frontal—just in front of the fissure of Rolando

(2) Superior frontal

(3) Middle frontal

(4) Inferior frontal—the left inferior frontal is known as "*Broca's convolution*" and it is centre for *speech*

BOUNDARIES OF THE PARIETAL LOBE

Front—the fissure of Rolando

Behind—the parieto-occipital fissure

Below—the horizontal limb of the fissure of sylvius

CONVOLUTIONS OF PARIETAL LOBE—

(1) Ascending parietal
(2) Superior parietal
(3) Supra-marginal gyrus
(4) Angular gyrus.

(Probably contains centre for sight)

OCCIPITAL LOBE—

It lies behind the parieto-occipital fissure

ITS CONVOLUTIONS ARE—

(1) Superior occipital
(2) Middle occipital
(3) Inferior occipital

BOUNDARIES OF THE EXTERNAL SURFACE OF THE TEMPRO-SPHENOIDAL LOBE

ABOVE—the horizontal limb of the fissure of Sylvius

BELOW—the inferior tempro-sphenoidal sulcus

BEHIND—it merges into the occipital lobe and angular gyrus

CONVOLUTIONS—

(1) Superior tempro-sphenoidal
(2) Middle tempro-sphenoidal.
(3) Inferior tempro-sphenoidal

STRUCTURE OF THE CEREBRUM

The cerebrum consists of *grey matter* coating externally, and the *white matter* lying internally

The grey matter enclosing the white matter is thrown as a thin sheet over the surface of the cerebrum, and forms convolution separated from each other by fissures

The white matter lying internally consists of nerve *fibres*

THE CORTEX consists of nerve-cells and nerve-fibres imbedded in a matrix, and some of them are derived from

white matter This is divided into five layers as follows —

(1) SUPERFICIAL LAYER —This is the most external layer, chiefly composed of neuroglia, with a few small multipolar nerve-cells

(2) A LAYER OF SMALL PYRAMIDAL CELLS.—This layer is composed of small angular pyramidal nerve cells The cells are small with processes which ramify

(3) A LAYER OF LARGE PYRAMIDAL CELLS —This layer consists of many layers of large pyramidal cells with branching processes running off to the free surface There is also a process from each cell which becomes continuous with axis-cylinder of nerve-fibre.

(4) A LAYER OF SMALL, BRANCHED, IRREGULAR CELLS

(5) A LAYER NEXT TO THE WHITE MATTER —This layer consists chiefly of spindle-shaped and branched cells which are parallel to the surface of the convolution This layer is divided into vertical columns by the white fibres coming from the white matter to the cortex

THE TOTAL NUMBER OF NERVE-CELLS IN THE CEREBRAL CORTEX OF MAN —

Miss H B Thomson has reported recently in the "Journal of Comparative Neurology" the total number of nerve cells in the human cerebral cortex The entire cortex was divided into *sixteen regions* A portion of each such region was separately examined, and the number of nerve-cells per cubic millimetre were estimated, the total cortical area was next calculated There are over 9,200 millions of nerve-cells in the cerebral cortex

FUNCTIONS OF THE CEREBRUM.

The cerebrum is the highest nerve-centre, viz , those whose activity is associated with *volition, intelligence, thinking, consciousness, motion* and *sensation* It was thought at first that the grey matter on the cortex of the brain was entirely concerned in the phenomena of *volition, intelligence* and *sensation* During the Franco-German

war in 1870 Hitzig had occasion to apply electric current to a portion of exposed brain of a wounded soldier, and he noticed contraction of the muscles of the eyeball Hitzig and Fritsch in Germany began to make experiments on lower animal

After exposing a portion of brain was irritated by electric current and observed all the phenomena occurred at the time They discovered that when the certain areas of grey matter were stimulated, contraction of certain muscles occurred Therefore by these experiments they were able to map out areas in the cortex for groups of muscles

Afterwards Ferrier, Horsley, &c, in London advanced the research, and obtained many important results, which are valuable in the diagnosis of various diseases of the nervous system

They made an experiment on living brain They stimulated certain areas, which caused definite and particular *movements*, and *sensations*, etc, on opposite side, and also examined the brains of patients who had died from cerebral disease, and they carefully compared the position of the disease when the symptoms appeared by the patients during life They discovered that certain parts of the cortex have special function allotted to them

THE LOCALIZATION OF THESE ARE BRIEFLY

(1) THE ROLANDIC AREA—concerned with motor functions

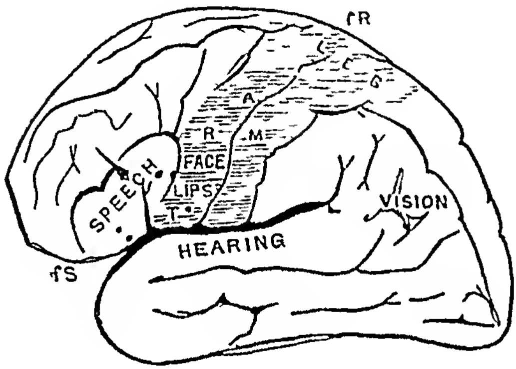
(2) THE OCCIPITAL LOBES—principally concerned with sensation

(3) THE FRONTAL LOBES—which are concerned in the higher *psychological* functions

1 THE MOTOR AREAS—The motor centres are situated at the fissure of Rolando in the region of the *ascending frontal* and *ascending parietal* convolutions

THE GENERAL ORDER IS FROM ABOVE DOWNWARD:—

Centre for the *legs*
Do for the *arms*
Do for the *face*
Do for the *lips*.
Do for the *tongue*
Do for the *trunk* lies between the leg and arm areas



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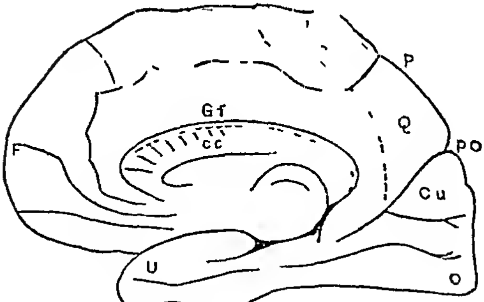


B

Fig 44

A Motor areas in man, shaded—outer surface of the left side of human brain

B Inner surface of right hemisphere

As=areas governing the movements of the arm and shoulder, Tr=of the trunk, Leg=of the leg, Gf=gyrus fornicatus, CC, corpus collosum, V=uncinate gyrus, O=occipital lobe

THE SPEECH Centre is situated in the inferior frontal of left side—"Convolution of Broca" (If the person be left-handed, the speech centre is in the *right* convolution)

APHASIA —This means loss of power of speech, this may be due to injury of the speech centre

SENSORY CENTRES

THE CENTRES OF SPECIAL SENSATIONS—

(1) SIGHT —It is placed in the *occipital lobe* and *angular gyrus* Destruction of these causes permanent blindness

(2) HEARING or auditory centre —In the *superior tempro-spheroidal* lobe Destruction of entire region causes deafness of the opposite side

(3) The centres for *smell* and *taste* are in the *hippocampal region*

The result of stimulation of all these centres is seen in the opposite side of the body

Destruction of cerebral cortex produces paralysis of the oppposite muscles of the body—*hæmiplegia*

Therefore cerebral centres preside over the other side of the body, *i e*,

Right side over the left and left over the right

PATHS OF CONDUCTION OF SENSORY AND MOTOR IMPULSES FROM AND TO CEREBRAL CORTEX.

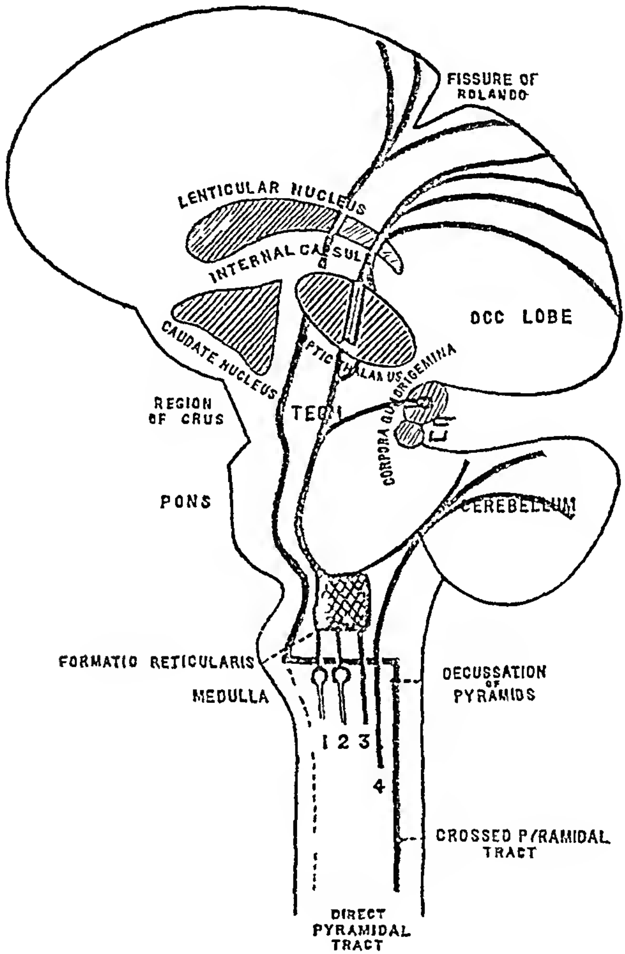


Fig 45

DIAGRAM to show the course of the principal motor (*green*) and sensory fibres (*red*) between the medulla and cortex (*Wheeler*)

PATHS OF MOTOR IMPULSES

Motor impulses start from the cortex, around the fissure of Rolando, they proceed through—

(1) Corona Radiata

(2) Anterior two-thirds of the *posterior* limb of internal capsule

(3) Crusta of crus

(4) Pons Varolii

(5) Medulla, where bulk of impulses cross (decussation of pyramids) to the opposite side, and pass down the cord as the *crossed pyramidal* tract, thence to the *multipolar cells* of the anterior horn of grey matter, finally out by the anterior motor roots to the muscles (see green part of Fig. 45)

PATHS OF SENSORY IMPULSES

Sensory impulses starting from the periphery to the spinal cord (see Spinal Cord)

The cord takes four distinct sensory railroads—viz , *Burdoch, Goll, Gower* and *direct cerebelar*

(1) Direct cerebellar goes direct to cerebellum.

(2) Gower's to the formatio reticularis

(3) Goll and Burdoch—end as clavi in the medulla

From each clavus fibres pass to the formatio reticularis.

Thus Goll, Burdoch and Gower are amalgamated at a common junction.

From this junction they pass upwards, their course being through—

1 Medulla

2 Pons

3 Tegmentum of crus

4 Posterior third, posterior limb of internal capsule

5 Crona radiata

6 Cortex, occipital lobe or special centres (see red part of the diagram)

TROPHIC CENTRE—It is placed in the cerebral cortex called " First Trophic Realm " Destruction of the cerebral cortex causes descending degeneration traced in the pyramidal tracts

RELATION OF CORTICAL CENTRES TO THE SURFACE OF SKULL.

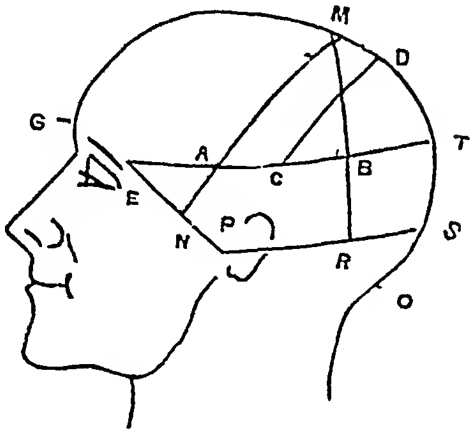


Fig 46

A line G O Glabella to Occ Pro Take midpoint M bisect MO, for T bisect TO, for S

Find Ext ang process E and root of *Zygoma*—P (points in front of and just above Ext *Aud* Meat)

Join EP, PS, ET

Bisect EP, and PS, as N and R Join MN and MR

Bisect AB at C and draw CD parallel to AM

The Pentagon *ACBRPN corresponds to the temporo sphenoidal lobe*, with exception of its apex, which is a little in front of N

MDCA, Rolandic area

PSYCHICAL FUNCTIONS OF THE BRAIN

The cerebral hemispheres are laid down as the seat of all the psychical actions Thus the frontal lobes appear to be located with *cognitions, volitions* and *intellectual* activities The capacity of intellectual power in the animal kingdom depends on the size of the brain The gradual development of the brain, as compared with that of the body, which is observed as we rise in the animal scale, has intimate proportional relation to a corresponding development of nervous and mental endowments

CIRCULATION IN THE BRAIN

Fresh supply of blood and return of venous blood are essential for cerebral activities The circle of Willes permits a free circulation within the cranium

CHAPTER XV.

REPRODUCTIVE ORGANS AND DEVELOPMENT.

MALE GENERATIVE ORGANS

THE TESTICLE.—The testicle is enclosed in a strong fibrous capsule, the *Tunica albuginea.* Externally covered by a serous membrane called *Tunica vaginalis* The tunica albuginea is prolonged at the posterior border of testes to form *Mediastinum Testes* The tunica albuginea sends numerous septa inwards, dividing the organ into a number of compartments—and in these the seminal tubes are lodged.

ARRANGEMENT OF SEMINAL TUBULES.

Each compartment contains several seminal tubules. They begin in blind ends, and very much convoluted at first, but as they approach the mediastinum testes they become straighter, forming the—

1 VASA RECTA—In the mediastinum they form network

2. *Retes testes*, from this the

3 *Vasa efferentia* arise, and, becoming much convoluted, form the conical eminence.

4 *Coni-vasculosi*, which form head of

5 *Epididymis*, which terminate into

6 *Vas deferens* about 20 feet long, and which is the excretory duct of the testes

STRUCTURE OF SEMINAL TUBULES

The tubules are lined by several layers of cubical cells resting on basement membrane

1 THE OUTER LAYER CELLS—Next to basement membrane

2 THE INNER LAYER CELLS —The cells are large, clear, with nuclei—the nuclei often divide to form daughter cells.

These daughter cells form *spermatozoa*

THE SEMINAL FLUID —Semen is made up of the secretions of the testicles, the seminal vesicles, the prostates, and Cowper's glands

PHYSICAL CHARACTER —The seminal fluid is sticky, odour of *raw potato*, whitish-yellow It is at first gelatinous, when it is exposed to the air, becomes more fluid, the amount of semen discharged is two drachms, and when repeated drains are made, only a few drops may appear

CHEMICAL COMPOSITION.

1 Water

2. Albumen.

(*a*) Serum—Albumen

(*b*) Alkali—Albumen.

(*c*) Nuclein, lecithin, cholesterine

3. Fats

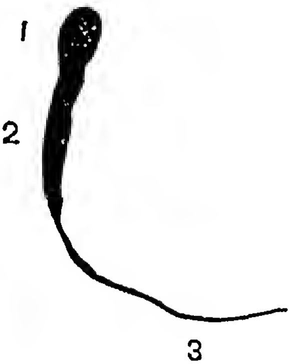


Fig 47 Spermatozoa

4 SALTS —Phosphates, sulphates, carbonates, chloride.

5 Spermatine

6 Seminal corpuscles with epithelial cells.

7 Spermatozoa

SPERMATOZOA.

THE PARTS OF SPERMATOZOA.

1 THE HEAD—pear-shaped

2 MIDDLE piece—rod-shaped

3 TAIL—long hair-like cilium

PASSAGE OF SPERMATOZOA

The spermatozoa, or life-giving elements of the semen, are secreted in the testicles, pass into the epididymis, and

carried from this tube by means of the Vasa differentia to the seminal vesicles and prostatic urethra

CHARACTER OF SPERMATOZOA

After discharge of seminal fluid in the vagina, immediately spermatozoa exhibits rapid movements for hours or days The movement is due to tail. Their movements are paralysed by water, alcohol, syrup of grape-sugar, and very alkaline and acid uterine and vaginal mucus

DEVELOPMENT OF SPERMATOZOA

The walls of seminal tubules are lined by nucleated cells These cells divide into daughter cells from which a column-like prolongation grows projecting into the lumen of tubule The prolongations break up into several oval globules—the *spermatoblasts*

Each lobule of spermatoblast elongates into a tail, while the deeper part forms the head and middle piece When the development is completed, the head and middle pieces are detached, and ultimately the remaining portion of spermatoblast undergoes fatty degeneration

ERECTION OF PENIS

"The penis is composed of many *erectile tissues* and *blood vessels* Erection is due to overfilling of the blood vessels and elongation of erectile tissues, whereby organ is increased four or five times, while at the same time temperature is increased and also there is higher blood-pressure.

This is reflex-motor act It is brought about into action by the sexual desire stimulating the sensorium Thence sexual impulses are transmitted to the spinal centre, by stimulation of erector nerves the erection of penis is resulted"

EMISSION AND RECEPTION OF THE SEMINAL-FLUID.

At the height of sexual excitement, the emission centre in the spinal cord is reflexly stimulated, and therefore there are peristaltic contractions

As a result of this contraction, and the simultaneous relaxation of the compressor urethræ, the semen is forced into the bulbus urethra From here it is driven forward by clonic contractions of the accelerator urinæ resulting into forcibly ejaculation of semen of *vesiculæ seminales*

IN THE FEMALE also, at the height of sexual excitement, there is a reflex movement corresponding to emission It consists of contraction of Fallopian tube and uterus The uterus is erected, and at the same time it descends towards the vagina When the uterus relaxes after the excitement, it asperates the seminal fluid into its own cavity

NERVE CENTRE FOR ERECTION

"The centre for erection in the cord is undoubtedly under the domination of the vaso-dilator centre in the medulla oblongata Psychical impressions have marked influence upon the vaso-dilator nerves When the thoughts are strongly directed towards sexual subjects, there results a powerful action upon the *nerve-erigentes* Thus sights, sounds, odors, memories, in fact all mental impressions which suggest sexual desire, may produce powerful erections"

FEMALE GENERATIVE ORGANS

I THE VAGINA is a curved canal lying in the axis of the pelvis, measuring 3½ inches in length

STRUCTURE—The vagina consists of three coats —

1 The mucous coat is lined by squamous epithelium, containing mucous glands and numerous papillæ It is thrown into rugaœ which are best marked in virgin and disappear after child-bearing

2. MUSCULAR COAT—Consists of longitudinal and transverse fibres

3 External coat of connective tissue which serves to attach the vagina to the rectum

II THE UTERUS—It is pyriform shape body placed parallel to the axis of the pelvic inlet. It is divided into a lower part, the *cervix,* and an upper part, the *body* At the two upper angles are the openings of the Fallopian tubes , between these openings there is a rounded border called *Fundus*

The uterus is a hollow body containing cavity inside The body is 3 inches long and the cavity is $2\frac{1}{2}$ inches including cervix; the cavity receives the openings of two Fallopian tubes

STRUCTURE—The uterus has three coats.

1. THE PERITONEAL COAT—It is loosely attached and covers the whole of the posterior surface, and upper three-quarters of the anterior surface.

2 THE MUSCULAR COAT—The muscular wall of the uterus is very thick, and consists of non-striped muscular fibres

3 THE MUCOUS COAT—The mucous membrane lines the cavity of uterus, and it grows thicker before each menstrual period It is reddish-grey in colour

III THE FALLOPIAN TUBES—The tubes are two in number, opening internally each side of uterus.

IV THE OVARIES—The ovaries are two oval bodies, seated in the folds of the broad ligaments They are connected with the upper angle of the uterus by a small band and with the Fallopian tube by means of fimbriated processes During menstruation the ovaries enlarge , after the menopause they become atrophied

The surface of the ovary before puberty is smooth, afterwards it becomes puckered owing to cicatrical contraction of the *Corpora lutea*

STRUCTURE OF THE OVARY—The ovary is chiefly made up of a *stroma,* consisting of connective tissue and non-striped muscular fibres. At the periphery the stroma is dense, and forms *cortex,* at the centre it is loose and vascular, forming the *medulla*

1. It is covered by short columnar epithelial cells; these cells are known as *germinal epithelium,* because from them that the ova is developed Beneath this is—

2 THE TUNICA ALBUGINEA—This is a firm fibrous layer

All through the stroma there are scattered *Graffian follicles*

STRUCTURE OF GRAFFIAN FOLLICLES —It consists of—

1. A tunica fibrosa

2 A basement membrane

3 A TUNICA GRANULOSA—Consisting of epithelial cells At one part these cells are collected into a heap, called the *discus proligerus,* in which is embedded the *ovum*

4. The cavity of the follicle is filled with *Liquor Folliculi*

THE OVUM—The ovum is a vesicle about $\frac{1}{180}$ inch in diameter consisting of —

1 THE ZONA PELLUCIDA or vitelline membrane, within this lies

2 THE YOLK, a yellow viscid fluid containing

3. THE GERMINAL VESICLE—inside this is

4 THE GERMINAL SPOT

DEVELOPMENT OF OVA

The ova are developed from the germinal epithelium.

The cells enlarge and grow down into the stroma, while the stroma grows up and include them A chief cell becomes the ovum, while the rest becomes the Tunica granulosa

FATE OF THE GRAFFIAN FOLLICLE

OVULATION—About the time of menstrual period a follicle becomes mature and very hyperæmic The follicle grows rapidly and reaches near the surface of ovary At the same time liquor folliculi increases to such a degree that due to the increase of pressure the follicle bursts, and

discharges its contents, consisting of the ovum and some cells of the *descus proligerus,* and brought into contact with the abdominal osteum of the Fallopian tube The ovum when discharged is carried towards the uterus by the ciliated epithelium

THE CORPUS LUTEUM is produced by the changes which occur in the Graffian follicle after expulsion of the ovum The cavity collapses

"The cavity is filled with *Tunica granulosa* and an effusion of blood which coagulates, new capillaries shoot in, the cells undergo fatty degeneration assuming a yellow colour If pregnancy does not take place, then the fatty matter is gradually absorbed, leaving a small spot of cicatrical tissue"

PUBERTY—The term puberty means power of procreating

THE MALE attains puberty at the age of 14 to 16 years and lasts up to old age In man, the formation of seminal fluid is observed up to old age

The larynx elongates and the thyroid becomes more prominent, while the voice is hoarse

THE FEMALE attains puberty at variable age In hot climate puberty may occur at the age of 10 years onwards, and in temperate region at the age of 13 to 16 years

SIGNS—The whole body fills out and becomes more rounded in contour The breasts develop and the hip widens considerably Hair appears on the pubis The larynx becomes longer and voice becomes changed Ovulation and menstruation commence, and reproductive life is begun From the period of puberty until the cessation of the menses, the sexual appetite occurs, and the ripe ova are discharged from the ovary

MENSTRUATION—Menstruation occurs at regular intervals after it is once established, while at the same time there is rupture of a mature Graffian follicle with discharge of ovum

"The periodicity of recurrence is called the menstrual type The type is determined by the number of days from the beginning of one period to the beginning of the next By far the commonest type is the 28 days, *i e*, women who are regular begin to menstruate on the same day of the week every four weeks Most women menstruate during the first quarter of the moon, and only a few at new and full moon It is characterised by discharge of blood lasting three to four days in temperate and in hot climate may last from five to seven days During pregnancy and lactation, menstruation and ovulation are generally stopped"

CHARACTER OF MENSTRUAL DISCHARGE

It consists of blood mixed with epithelium, mucous and débris, it is faint heavy odour The discharge is derived from the uterine mucous membrane, which becomes congested and swollen, and then breaks up, leaving the vessels beneath exposed

MENOPAUSE—This means cessation of menstrual discharge It occurs normally between the ages of 35 and 55 years As a general rule, when menstruation begins late, it will end early, and *vice versâ*, early puberty will indicate a late menopause In hot climates, the reproductive life is short, puberty and menopause alike occur very early Some women tend to general adiposity some become thin, and muscular

NUBILITY—"Suitable age for marriage Though reproductive life begins at the early age, by no means this age is proper marriageable time Pregnancy and labour may be associated with a great risk to mother, and may bear unhealthy children The children of immature parents are often weak and ill-developed, they are liable to the attacks of many grave diseases, and very frequently die before reaching adult life The best age for women to marry is 20 years onwards At this age women will have very little risk to their own life and the children The children of old age are of low vitality and poor in powers of resisting diseases They often look older than their age."

CONCEPTION—At every menstrual period coitus may be followed by pregnancy It is said that pregnancy may take place usually within two weeks after a menstrual period

DEVELOPMENT

FROM FOTHERGILL

MATURATION OF OVUM—Changes occur in the ovum before impregnation The germinal vesicle and germinal spot disappear so that the egg becomes a mass of protoplasm. The nucleus reappears, and divides into two halves One half of the nucleus is pushed out from the cell, the process is known

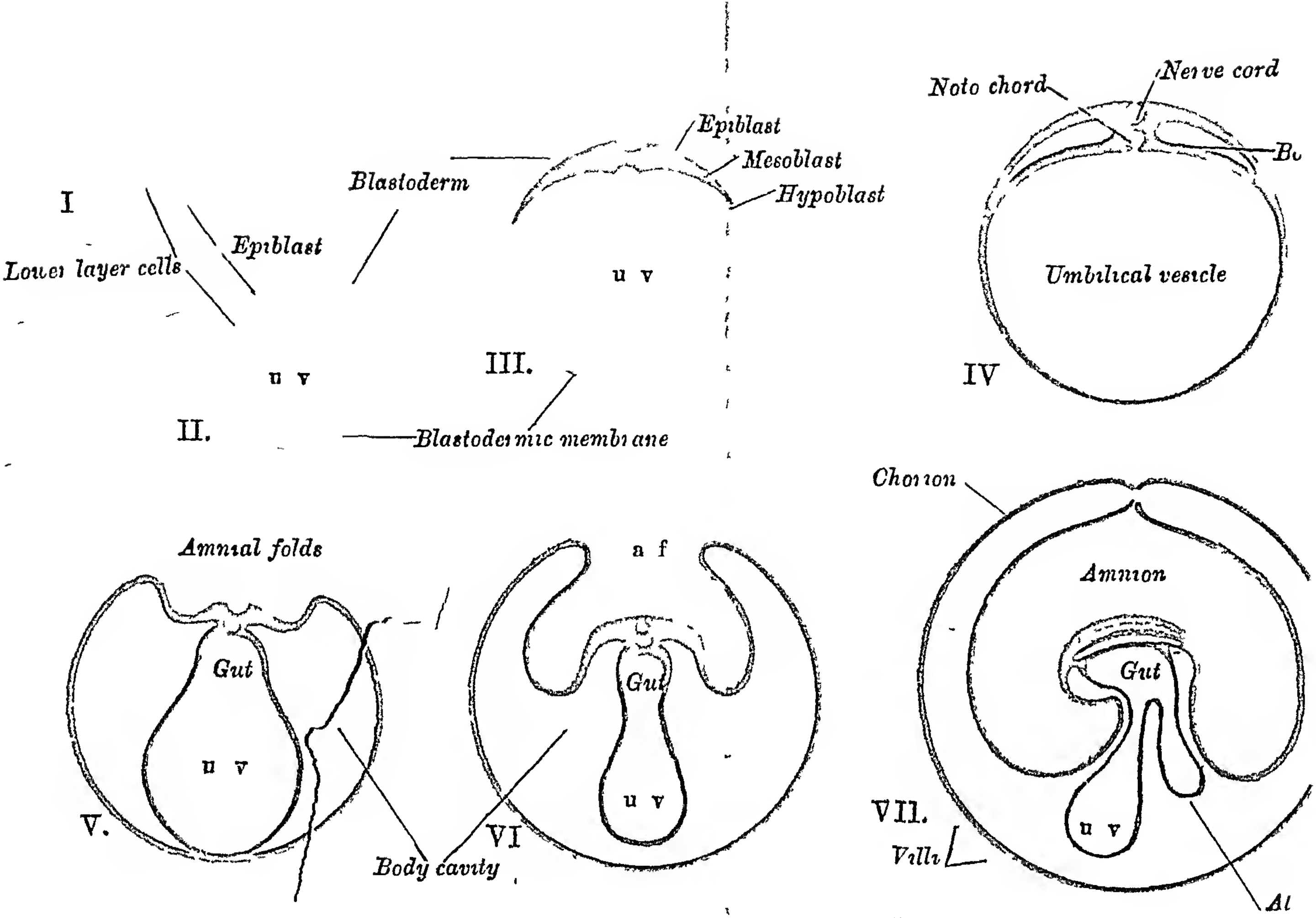
FIRST POLAR BODY and the remaining part remains in the centre to form the *Female pronucleus.*

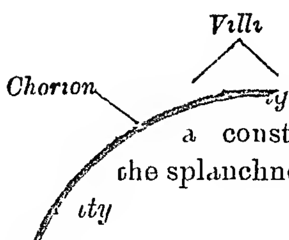
IMPREGNATION—It occurs in the cavity of fallopian tube A single spermatozoa penetrating the zona pellucide enters the ovum It moves towards the *female pronucleus* and loosing its tail, the head forms *male pronucleus* And now the changes are—

I The *male* and *female* pro-nuclei fuse together to new nucleus of *fertilised ovum* The ovum now travels towards the uterus, and then the process of segmentation takes place

SEGMENTATION—The ovum divide into two cells and each of these into two again and so on until a rounded mass *Morula* (mulberry) is formed The morula consists of two kinds of cells Those on the surface are *epiblast*, those enclosed within are the *lower-layer-cells* (*blastoderm*) from which *hypoblast* and the *mesoblast* are derived

II BLASTODERM—The ovum later on has become a hollow *sac*, the *blastodermic vesicle* contain fluid The wall of this sac is the blastodermic membrane, consisting—the outer *epiblast*, and the inner *lower-layer cells* At one spot the blastoderm is *thick*, which is the area of *germination* or embryonal area.





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III FORMATION OF MESOBLAST AND HYPOBLAST—The lower-layer-cells of blastoderm give origin to the *hypoblast* lining the vesicle and the *mesoblast* lying between the hypoblast and the epiblast Thus the ovum is now into three layers, viz, *epiblast* externally and *mesoblast* in the middle and *hypoblast* internally The mesoblast is very thick at the germinal area

IV THE CHANGES IN EPIBLAST, HYPOBLAST AND MESOBLAST

(*a*) EPIBLAST—Epiblast thickens to form the *medullary plate* in which *medullary groove* appears—lateral ridges meet over this groove, and convert it into neural canal, from which central nervous system is developed

(*b*) MESOBLAST—forms lateral plates on each side of noto-chord which is *proto-vertebræ*

(*c*) HYPOBLAST forms the noto-chord and it forms the lining of the alimentary canal

SPLITTING OF MESOBLAST—Mesoblast splits into two layers The outer layer adheres with the epiblast called *somatapleure* and inner with the hypoblast called *splanchnopleure*

V FORMATION OF SOMATAPLEURE AND SPLANCHNOPLEURE—The splitting of the mesoblast continues all round the blastodermic vesicle. So that two vesicles are formed the one inside the other The outer vesicle is of *somatopleure,* the inner is of *splanchnopleure,* and attached to one another *only where the spinal column of the fœtus is forming* At this stage blastodermic vesicle forms a constriction, and between the somatopleure and the splanchnopleure is a space The space forms *body-cavity*

Above the constriction is embryonic somatopleure, and below it extra-embryonic somatopleure, and also in splanchnopleure, above is embryonic and below is extra-embryonic splanchnopleure

VI UMBILICAL VESICLE—The extra-embryonic splanchnopleure is called now umbilical vesicle, which is continuous with rudimentary alimentary canal (gut)

VII CHORION AND AMNION—The fœtus and the umbilical vesicle sink down, and the extra-embryonic somatopleure rise round the embryo The two folds meet each other over the back of embryo The embryo is thus enclosed in a sac— the sac is *Amnion* The outer covering is *Chorion* with *Villi*

VIII ALLANTOIS—A diverticulum is pushed out from the gut This diverticulum is the alimentary canal The embryo is now taking shape, and lies in fluid contained in *amnion* The neck of amnion narrows to form a tube Within this tube are two smaller tubes, namely the stalk of umbilical vesicle and the *allontois*

IX The formation of --

(1) CORD—The neck of the amnion closes on the stalks of the umbilical vessels and the allantois to form rudiment of *umbilical cord*

(2) MEMBRANES—The amnion fuse with chorion to form *fœtal membrane*

(3) PLACENTA—The sac of the allantois becomes flattened between the amnion and the chorion, and both unite with it in the site of the rudiment of the *placenta*

FORMATION OF THE PLACENTA

"The villi of the chorion dip into the *decidua serotina* and *decidua reflexa* of uterine mucosa Afterwards the chorionic villi in contact with the decidua reflexa lose their vessels and become atrophied, the villi, however, in contact with the serotina undergo great increase in size and vascularity, and form the fœtal part of the placenta At the same time a similar increase in size and vascularity takes place in the decidua serotina, forming the maternal part of the placenta."

STRUCTURES DERIVED FROM EPIBLAST, MESOBLAST AND HYPOBLAST.

EPIBLAST	MESOBLAST	HYPOBLAST
1 Epidermis 2 Epithelium of the nose and mouth 3 Brain, spinal cord and nerves 4 Parts of the eye and ear	All other tissues and organs.	1 Epithelium of the pharynx and alimentary canal below it 2 Epithelium of lungs, urinary bladder and urethra.

NOTOCHORD

It is a column of cells derived from hypoblast lying just beneath the nerve cord, and occupying the place of the future bodies of the vertebræ from which vertebræ are developed

THE FŒTUS

CHIEF CHARACTERS OF THE FŒTUS AT DIFFERENT STAGES OF DEVELOPMENT

1st Month—The embryo is about the size of a pigeon's egg The umbilical vesicle and amnion are formed

2nd Month—The embryo is about the size of a hen's egg Ossification in the jaw has commenced The permanent kidneys have appeared, and reproductive organs are formed

3rd Month—The embryo is about the size of a goose egg The placenta is formed The *anus* and mouth are closed The external genitals begin to show differentiation of sex, nails become visible

4th Month—The fœtus is 4—6 inches in length The sex is distinguishable The anus and mouth are opened The muscles are formed

5th Month—The fœtus is 10 inches in length The hair begins to appear and skin is covered with varnix

6th Month—The fœtus about a foot in length The eyelids are formed The testes lie near the kidney

7TH MONTH—The length is 15 inches The eyelids are open The testes are descending

8TH MONTH—The length is 16 to 18 inches, ossification is going on in the lower end of the femur The skin is red

9TH MONTH—The length is 18 to 20 inches The testes have reached the scrotum and assume the appearance of full-time child

DEVELOPMENT OF THE HEART

The heart is at first represented by *two tubes* placed side by side, which very soon fuse into a *single tube* Two transverse constrictions appear in the tube, dividing it into following chambers—*primitive auricle, arterial bulb* (truncus communis arteriosus), and *primitive ventricle* Later on the heart becomes twisted upon itself, so that the auricle gets on the top of the ventricle and the ventricle increases in size

A septum appears which grows upwards from the apex of the ventricle, dividing the single cavity into two

After the ventricular division is completed, a septum appears at the upper part of the single auricle, and grows downwards, dividing it into two auricles, an opening, however, exists in this septum during the whole of intra-uterine life, called the *foramen ovale* It should close up a few days after birth A partition also grows in the *arterial bulb*, dividing it into the ascending aorta, and the trunk of the pulmonary artery

SHORT ACCOUNT OF THE VASCULAR ARCHES

The bulbus arteriosus bifurcates into the two aortic roots The arches these form make the first pair of vascular arches

There are five arches on each side—

- The *first and second disappear*
- The *third forms the internal carotids*
- The *fourth left becomes the arch of the aorta*
- The fourth right becomes the *innominate artery*, and part of the right subclavian
- The fifth *left becomes the ductus arteriosus*
- The fifth *right disappears*

RECURRENT BRANCHES OF THE VAGUS

"At first the heart is in the neck, and the vagus gives off its recurrent branch opposite the fifth vascular arch, round which it turns to the larynx As the heart sinks down into the chest, this branch is stretched, and as the fifth right arch disappears, the right nerve turns round the fourth right arch—*i e*, the first part of the subclavian The fifth left arch remains as the *ductus arteriosus*, and the left nerve bends below this before it ascends behind the arch of the aorta"

EARLY VEINS OF THE FŒTUS

"The first veins are the *omphalo-mesenteric*, from the vascular area in the wall of the umbilical vesicle, they join and open into the primitive auricle

Then in the wall of the chorion, two umbilical veins appear about the fourth week At the fifth week one disappears, and the other remains as the umbilical vein The omphalo-mesenteric and umbilical veins are visceral veins

There are also parietal veins—the cardinal and the jugular. The cardinal veins return the blood from the Wolffian bodies and the walls of the trunk Two primitive jugular veins are developed in the head and neck, and return the blood from these regions The primitive jugular and cardinal vein, on each side, join in the cervico-thoracic region to form a vein called the duct of Cuvier"

FŒTAL CIRCULATION

"The blood from the inferior vena cava is mixed—impure from the lower part of the body, and purified from the placenta It flows into the right auricle, and, guided by the Eustachian valve, passes through the patent foramen ovale into the left auricle, then to the left ventricle, and thence to the head, neck, and upper limbs, very little passing through the descending aorta"

"The blood from the superior vena cava is entirely venous, and passes into the right auricle, then to the right ventricle, and into pulmonary artery, and passes through

the ductus arteriosus into the descending aorta, very little passing into the right and left pulmonary arteries. This blood supplies the lower parts of the body, and then passes to the placenta to be purified, by means of the hypogastric arteries"

"From the placenta the blood is returned by the umbilical vein. This vein, when it reaches the liver, divides into two branches—one communicates with the portal vein, the other, the ductus venosus, joins the inferior vena cava"

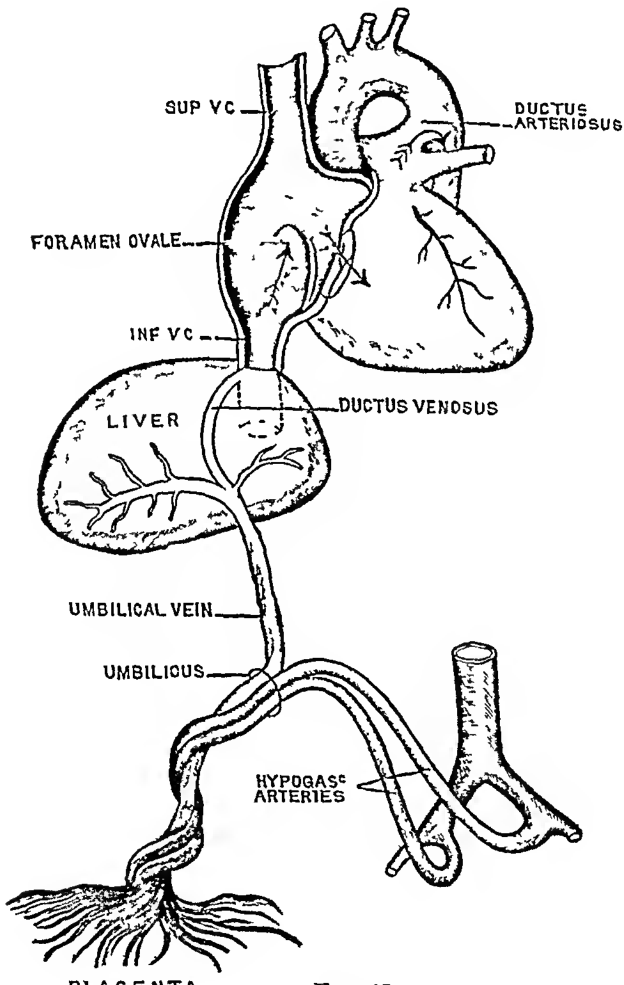

Fig 48

WHAT ARE THE WOLFFIAN BODIES.

"They *are the primordial kidneys* They appear about the third week, being formed from the *intermediate cell mass* of the mesoblast In this a tube appears with diverticuli and vascular glomeruli The duct opens into the *cloaca* Up to the sixth or seventh week, they fulfil the office of kidneys, after that they atrophy In the adult male, the "*organ of Giraldes," and the vas aberrans are the remains of the Wolffian body*, in the adult female, the "grains of Folin," near the parovarium, are its persistent representatives"

"The *permanent kidneys arise from a mass of mesoblastic cells at the back of the Wolffian body*

The *urinary bladder is formed by a dilatation of the intra-abdominal part of the allantois*"

DEVELOPMENT OF GENITAL GLANDS

"They arise (*i e*, the ovary and testes) in close relation to the Wolffian body, from the same 'intermediate cell mass'"

What is the Use of the "Small Body" at the summit of the Wolffian Body?

"*It is converted in the male into the vasa efferentia coni vasculosi, and globus major of the epididymis*"

"FATE OF THE DUCT OF THE WOLFFIAN BODY?

In the male, it is converted into the body and globus minor of the epididymis, the vas deferens, and the common ejaculatory duct, whilst the vesicula seminalis arises as a diverticular prolongation from it"

"In the female, it almost entirely disappears, but it forms in certain animals the tubes called the 'canals of Gartner'"

DUCT OF MULLER

"It is a slender tube on each side lying on, but not communicating with, the Wolffian body The anterior ends open into the peritoneal cavity, the posterior ends become fused together."

"In the male they almost entirely disappear, and are represented in the adult by the pedunculated hydatid of

Morgagni, situated at the summit of the testicle, which is the persistent remains of the anterior end of the duct, and by the *vesicula prostatica (sinus procularis,* or *uterus masculinus)* "

" In the female, they become greatly developed, and form the genital passages and tubes The anterior end of each duct remains distinct, and form the Fallopian tubes, whilst the posterior coalesced portions are converted into the uterus and vagina "

DESCENT OF THE TESTICLE

"The testicles are originally situated in the abdomen, below the kidneys and behind the peritoneum Up to about the sixth month of fœtal life, they are found below the kidney, after that they gradually descend, so that by the seventh month, they are situated behind the internal abdominal ring During the eighth month they pass through the canal, and by the end of the ninth month they have reached the bottom of the scrotum In some mammals—*e g*, the elephant—the testes remain permanently within the abdomen, and in the rodentia they only descend at each 'rutting' season "

NOURISHMENT OF FŒTUS

It is nourished—

1 By the *contents of the umbilical vesicle*
2 By the *villi of the chorion*
3 By the *placenta*

FUNCTIONS OF THE PLACENTA

1. It is a respiratory organ
2 It is an alimentary organ
3 It is an excretory organ

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